AD-A105 535 INTERNATIONAL ENGINEERING CO INC SAN FRANCISCO CA F/G 13/13
NATIONAL DAM SAFETY PROGRAM. ST. JOE STATE PARK DAM (MO 30277), --ETC(U)
FEB 80 K B KING, S H KLINE, J H GRAY DACW43-79-C-0037

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MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

LEVEL II

ST. JOE STATE PARK DAM
ST. FRANCOIS COUNTY, MISSOURI
MO 30277

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
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St. Louis District

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

FEBRUARY 1980

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD-A105535

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Phase I Dam Inspection Report
National Dam Safety Program
St. Joe State Park Dam (MO 30277)
St. Francois County, Missouri

5. TYPE OF REPORT & PERIOD COVERED
Final Report

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
International Engineering Company, Inc.

8. CONTRACT OR GRANT NUMBER(s)
15 DACW43-79-C-0037

9. PERFORMING ORGANIZATION NAME AND ADDRESS
U.S. Army Engineer District, St. Louis
Dam Inventory and Inspection Section, LMSED-PD
210 Tucker Blvd., North, St. Louis, Mo. 63101

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Engineer District, St. Louis
Dam Inventory and Inspection Section, LMSED-PD
210 Tucker Blvd., North, St. Louis, Mo. 63101

12. REPORT DATE
Feb[redacted]980

13. NUMBER OF PAGES
Approximately 180

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
6 National Dam Safety Program. St. Joe State Park Dam (MO 30277), Mississippi - Kaskaskia - St. Louis Basin, St. Francois County, Missouri. Phase I Inpsection Report.

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16.
12 211

Approved for release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
10 Kenneth B. /King Stanley H. /Kline
James H. /Gray

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

LMSED-P

SUBJECT: St. Joe State Park Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of St. Joe State Park Dam (MO 30277):

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. The original dam of St. Joe State Park Dam, which has no spillway, will retain less than one-half the Probable Maximum Flood without the original dam being overtopped.

b. Overtopping could result in failure of the original dam.

c. Dam failure significantly increased the hazard to life and property downstream.

For Phase I reports, the extent of the downstream damage zone has been determined assuming that all the materials contained by the St. Joe State Park Dam are in a liquid state.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 23 JUL 1980 Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 24 JUL 1980 Date

ST. JOE STATE PARK DAM

ST. FRANCOIS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30277

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY

INTERNATIONAL ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
SAN FRANCISCO, CALIFORNIA

UNDER DIRECTION OF

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

FEBRUARY 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	St. Joe State Park Dam
State	Missouri
County	St. Francois
Stream	Shaw Branch (also known as Davis Creek)
Date of Inspection	25 and 26 August 1979

The St. Joe State Park Dam, I.D. No. 30277, was inspected by two civil engineers from International Engineering Company, Inc., of San Francisco, California. The dam is owned by the State of Missouri. The purpose of the inspection was to assess the general condition of the dam with respect to safety. The assessment was based upon an evaluation of the available data, visual inspection, and an evaluation of the hydrology and hydraulics of the site to determine if the dam poses hazards to human life or property. The purpose of the dam is to impound lead tailings and water.

The St. Joe State Park Dam was inspected using the "Recommended Guidelines for Safety Inspection of Dams" furnished by the Department of the Army, Office of the Chief of Engineers. Based on these Guidelines, this dam is classified as large. The St. Louis District Corps of Engineers has classified this dam as having a high downstream hazard potential to indicate that failure of this dam could threaten life and property. The estimated damage zone provided by the St. Louis District Corps of Engineers extends approximately twenty miles downstream of the dam. The town of Flat River, two highways, and many dwellings and buildings are within this damage zone.

The St. Joe State Park Dam is comprised of a main cross-valley dam adjoining an original valley-side dam which has an embankment across the back of the original dam pond. The watershed above the main dam is designated as subarea 1. The watershed above the embankment across the back of the original dam pond is designated as subarea 2, and the incremental area between this embankment and the original dam is designated as subarea 3. The results of the inspection and evaluation of the main dam indicate that the combined capacity of the outlet structure and spillways does not meet the criteria given in the Guidelines for a dam with the size and hazard potential of the St. Joe State Park main dam. As a large dam with a high hazard potential, the Guidelines specify that the discharge capacity and/or storage capacity should be capable of safely handling the Probable Maximum Flood (PMF) without overtopping the crest. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

It was calculated that the outlet structure at the main dam can pass a 100-year flood (a flood having a one percent chance of being equalled or exceeded in any one year) without the reservoir reaching either spillway crest. It was also estimated that the outlet structure and spillways can pass about 83 percent of the PMF without overtopping the dam and without significant erosion of spillway A or the embankment. Erosion of the spillway B channel will not endanger the embankment.

The results of the inspection and evaluation of the original dam indicate an absence of facilities for discharging flood water from subarea 3, inadequate freeboard, and that the dam does not meet the criteria given in the Guidelines for a structure with the size and hazard potential of the St. Joe State Park original dam. As a large dam with a high hazard potential, the Guidelines specify that the discharge capacity and/or storage capacity should be capable of safely handling the PMF without overtopping the crest. It was calculated that the original dam can retain the 100-year flood without overtopping the crest. It was also estimated that the dam can retain about 43 percent of the PMF without overtopping the crest; however, the dam can not retain 50 percent of the PMF without overtopping the embankment.

There are deficiencies that affect the stability of both the main and original dams, and that should be corrected. The capacity of spillway A should be increased and/or adequate freeboard provided at the main dam so that the PMF can be passed without overtopping the dam crest and without significant erosion of spillway A or the embankment. Additional freeboard should be provided along the east side of the spillway A channel upstream of the dam to keep it separated from the impoundment during periods of large flood runoff. Large rock should be placed at the entrance to the spillway A channel for erosion protection, and the dense brush and trees growing in front of the channel entrance should be cleared. Additional freeboard should also be provided along the ridge of the left abutment hillside between spillway B and the main dam crest to prevent overtopping of the ridge into the adjacent drainage west of the dam. An evaluation should be made of the effects of flood runoff which would pass through spillway B to determine whether this low point in the terrain of the left abutment hillside should be allowed to function as a spillway or should be filled in to prevent flood runoff from entering the adjacent drainage.

Adequate overflow facilities and/or freeboard should be provided at the original dam so that the impoundment (subarea 3) can handle the PMF without overtopping the dam crest and without significant erosion of the embankment. Erosion protection adequate to prevent siltation and undermining of the outlet of the culvert passing beneath the embankment at original dam Station 58+80 should be provided. An evaluation should be made of the effects of flood runoff which would pass through a low point in the natural terrain in subarea 2, designated as spillway C. The evaluation should determine whether this low point upstream of the railroad embankment across the back of the original dam pond should be allowed to function as a spillway or should be filled in to prevent flood runoff from entering the neighboring drainage north of the dam. Dependent

upon this investigation, the capacity of spillway C should be increased and/or freeboard should be increased along the railroad embankment to prevent overtopping of the embankment which might cause a sudden release of water into the original dam pond and overtopping of the original dam. An alternative would be to remove a portion of the railroad embankment to eliminate the storage effect of the embankment above the original dam. A re-evaluation of the hydraulic and hydrologic analyses of subareas 2 and 3 should be done in conjunction with an evaluation of the above alternatives. Remedial work on the main and original dams should be performed under the direction of a professional engineer experienced in the design and construction of tailings dams.

Seepage and stability analyses for the original dam and seepage analyses for the main dam comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" are not available. These studies should be performed by a professional engineer experienced in the design and construction of tailings dams and should be made a matter of record. The necessary data for these analyses would be obtained from additional investigations. The investigations would consist of field exploration and soil sampling, a laboratory testing program, and an engineering study to evaluate the stability of the dams including an evaluation of the liquefaction potential of the original dam. Based on the results of these analyses, remedial measures may become necessary. Stability analyses available for the main dam are adequate to show that (1) the factors of safety do not meet the requirements of the Guidelines, (2) the dam could be susceptible to liquefaction under certain earthquake loadings, and (3) the stability of the dam is not adequate. An evaluation should be made to determine feasible and economical measures to increase the stability of the dam to meet the requirements of the Guidelines. Additional stability studies of the main dam should be performed for appropriate loading conditions, including earthquake loads, in conjunction with any evaluations made to increase the stability of the dam and should be made a matter of record. Attention should be given to a more detailed study of the seismicity of the site, the response of the dam, and the seismic parameters of the materials in conjunction with future stability evaluations and recommendations. Remedial work should be performed under the direction of a professional engineer experienced in the design and construction of tailings dams.

An inspection and maintenance program should be initiated. Periodic inspections should be made and documented by qualified personnel to observe the performance of the dams, outlet structure, and spillways.

It is recommended that the owner take action to correct the deficiencies described.

Kenneth B. King

Kenneth B. King, P.E.

Stanley H. Kline

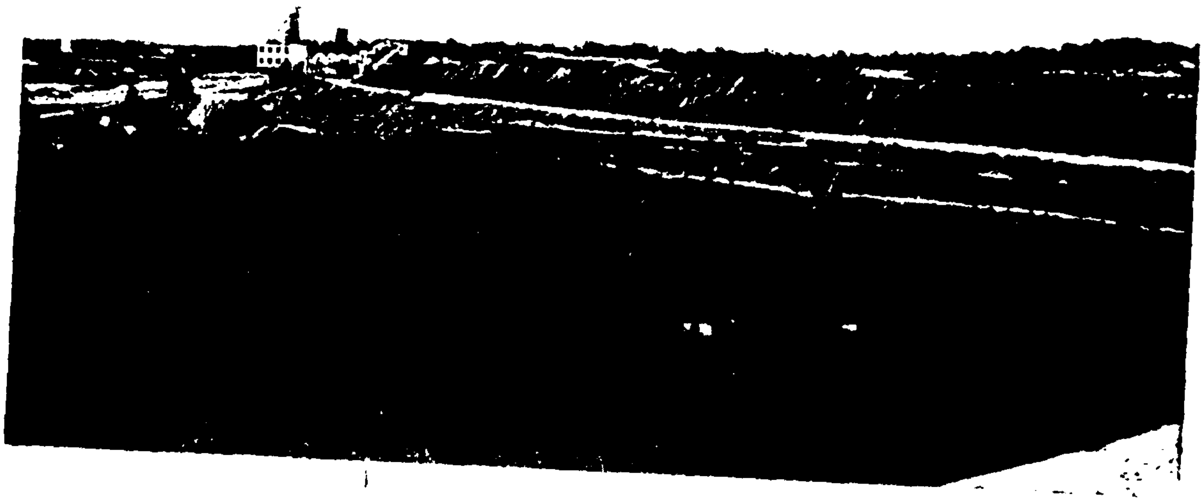
Stanley H. Kline, P.E.

James H. Gray

James H. Gray, P.E.

OVERVIEW OF ST. JOE STATE PARK DAM - I.D. NO. 30277

VIEW OF MAIN DAM FROM CREST OF ORIGINAL DAM



OVERVIEW OF ST. JOE STATE PARK DAM - I.D. NO. [illegible]
VIEW OF ORIGINAL DAM FROM CREST OF MAIN DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ST. JOE STATE PARK DAM
I.D. NO. 30277

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HYDROLOGIC AND HYDRAULIC ANALYSES

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ST. JOE STATE PARK DAM - ID NO. 30277

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the St. Joe State Park Dam be made and authorized International Engineering Company, Inc. to make the inspection.

b. Purpose of the Inspection. The purpose of the inspection was to assess the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in the "Recommended Guidelines for Safety Inspection of Dams". These Guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dams and Appurtenances. The St. Joe State Park Dam is actually two dams which will be discussed separately throughout most of this report. The first dam built at the site, referred to in literature as the Davis Creek Slime Pond, will be called the "original dam" in this report. The second dam built at the site, referred to in literature as the Davis Creek Dam, will be called the "main dam" in this report. The right end of the main dam at main dam Station 31+70 abuts the original dam at original dam Station 21+41 (Plates 3A and 3B).

(1) Main Dam

(a) The St. Joe State Park main dam is a cross-valley dam constructed with rockfill. The initial rockfill starter dam was raised with sand and silt sized lead tailings and faced with rockfill. The dam retains lead tailings, which consist of loose, saturated fine sand and silt.

(b) The spillway is an uncontrolled open channel of trapezoidal cross section located at the left abutment. A low point in the terrain of the left abutment hillside upstream of the dam would function as an auxillary spillway allowing flood discharge to flow into an adjacent drainage. The spillway at the left abutment and the low point that would act as an auxillary spillway will be referred to as "spillway A" and "spillway B", respectively, in this report and on the plates. A reinforced concrete outlet structure consisting of a 70-foot tall intake tower with twin 8-foot by 8-foot vertical shafts and a 310-foot long tunnel beneath the dam composed of twin 8-foot by 8-foot outlet conduits also serves to discharge reservoir water. A low level intake shaft at the east side of the tower which feeds into a 30-inch diameter steel outlet pipe will not discharge reservoir water because a valve at the outlet end of the pipe is closed.

(2) Original Dam

(a) The St. Joe State Park original dam is a U-shaped, valley-side dam consisting of rockfill and spigoted tailings. An embankment across the back of the pond, which will be called the "railroad embankment" in this report, forms an enclosed impoundment. The dam retains sand and silt sized lead tailings.

(b) Three outlet structures, all of which are considered to be nonfunctional, exist. A reinforced concrete intake structure with a 24-inch diameter steel pipe passing beneath the north leg of the dam which served as the feed line to the mill is closed. Two reinforced concrete vertical outlet towers and tunnels are located along the west leg of the dam. The outlet of tower and tunnel #1 is almost completely plugged with silt, and the outlet of tower and tunnel #2 is bulkheaded and buried. The original dam has no spillway to discharge floodwater from subarea 3. Overflow would pass over the dam crest low point at original dam Station 33+60 (Plates 3B and 4D).

b. Location. The dam is located in the central portion of St. Francois County, Missouri, as shown on Plate 1. The dam, shown on Plate 2, is located in Sections 17 and 18, Township 36 North, Range 5 East.

c. Size Classification. St. Joe State Park Dam is greater than 100 feet high; therefore, this dam is classified as large in accordance with the "Recommended Guidelines for Safety Inspection of Dams".

d. Hazard Classification. This dam is classified as having a high hazard potential by the St. Louis District Corps of Engineers. The esti-

mated damage zone, as provided by the St. Louis District Corps of Engineers, extends approximately twenty miles downstream of the dam. The town of Flat River, two highways, and many dwellings and buildings are within this damage zone.

e. Ownership. This dam is owned by:

State of Missouri
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65101

f. Purpose of Dam. The purpose of the dam is to impound lead tailings and water.

g. Design and Construction History. Construction of the original dam began in the early 1900's when the St. Joseph Lead Company's Federal Division mill was built in 1906. No design or construction records are known to exist for the original dam.

Construction of the main dam began in July 1942. An initial rockfill starter dam was built of coarse gravels and boulders and keyed into bedrock. The dam was made impervious by dumping minus 2-inch material on the upstream face and subsequently covering this with tailings that decreased in particle size in the upstream direction. The initial dam was raised by deposition of lead tailings from a pipeline on the tailings just upstream of the crest. A facing of rockfill was placed on the downstream slope of the tailings as the dam was raised. The top portion of the dam was raised by adding rockfill at the crest to retain the lead tailings and water deposited by gravity flow into the impoundment upstream of the dam.

The tailings deposition operation ceased after 1965. Between 1972 and 1976 the St. Joe Minerals Corporation undertook a program of removing its mining facilities, and in the fall of 1976, the State of Missouri obtained the land, including the tailings impoundment, for the St. Joe State Park as a donation from the St. Joe Minerals Corporation. The design and construction information available is discussed in Section 2.

h. Normal Operating Procedures. No information was available describing how tailings deposition was carried out at the original dam. After construction of the initial embankment of the main dam, lead tailings were discharged in a slurry form from a pipeline from the mill and deposited by gravity flow into the impoundment along the dam crest. After the main dam reached a level of about El. 830 feet, the tailings were discharged upstream of the dam and deposited by gravity flow into the impoundment and toward the dam. Water decanted at the main dam was either pumped directly to the mill or pumped into the original dam impoundment which functioned as a mill water supply pond after tailings deposition started behind the main dam. The recycled water was used in the milling operation. Tailings are no longer conveyed to either the original dam or the main dam impoundments.

The outflow of surface runoff impounded by the original dam in subarea 3, if great enough, would pass over the dam crest low point at original dam Station 33+60 (Plates 3B and 4D). The three outlets at the original dam are considered nonfunctional. The outflow of surface runoff impounded by the main dam would pass through an uncontrolled vertical intake tower with twin 8-foot by 8-foot outlet conduits located between main dam Station 7+00 and 8+00. Outflow, if great enough, would also pass through an uncontrolled, open channel spillway, spillway A, located at the left abutment of the main dam and over a low point in the terrain of the left abutment hillside upstream of the dam, spillway B, into an adjacent drainage. Outlet structures at the main dam do not require operation, and no operating records for either the original dam or the main dam are known to exist.

1.3 PERTINENT DATA

Data presented in this section was obtained from the St. Joe State Park, Mo., May 1976, 1 inch = 1000 feet scale, 10-foot contour topographic map, and the 1 inch = 100 feet scale, 2-foot contour topographic maps prepared for the Missouri Department of Natural Resources, Division of Parks and Recreation by Western Air Maps, Inc. of Lenexa, Kansas and from field measurements made on the dates of inspection (25 and 26 August 1979). The data is presented on Plates 3 through 8.

a. Drainage Areas.

(1) Main dam - 2771 acres.

(2) Original dam - 405 acres (including area above railroad embankment across the back of the pond).

b. Discharge at Damsite.

(1) Main dam

(a) Outlet structure discharge for pool at top of dam (El. 895.0 feet) - 4500 cfs.

(b) Spillway A discharge for pool at top of dam (El. 895.0 feet) - 4900 cfs.

(c) Spillway B discharge for pool at top of dam (El. 895.0 feet) - 2150 cfs.

(d) Maximum experienced outflow at damsite - No available information.

(2) Original dam

(a) Outlet pipe - All outlets at this dam are considered nonfunctional. Not applicable.

(b) Spillway - There is no spillway at this dam for subarea 3. Not applicable.

(c) Maximum experienced outflow at damsite - No available information.

c. Elevation (Feet above M.S.L.)[1/]

(1) Main dam

(a) Top of dam - Varies from El. 895.0 to El. 906.3.

(b) Streambed at downstream toe of dam - El. 764±.

(c) Maximum pool (PMF) - El. 895.7.

(d) Operating pool - No pool behind dam on 26 August 1979. Not applciable.

(e) Spillway A crest - El. 886.3.

(f) Spillway B crest - El. 890.1.

(g) Top of intake tower - El. 875.9 at low level intake, El. 879.8 at level of lower openings, El. 885.8 at level of upper openings, El. 891.8 at top of tower.

(h) Invert at end of outlet conduits - El. 820.0±.

(i) Tailings surface adjacent to dam - Varies from El. 874.2 to El. 883.5.

(2) Original dam

(a) Top of dam - Varies from El. 901.7 to El. 921.5±.

(b) Downstream toe of dam at maximum section - El. 782±.

(c) Maximum pool (PMF) - El. 902.4.

(d) Operating pool - El. 888± on 25 August 1979.

(e) Tailings surface adjacent to dam - No distinct division between dam and tailings surface.

1/ Elevations are based on contours and spot elevations from the St. Joe State Park, Mo., May 1976, 1 inch = 100 feet scale, 2-foot contour topographic maps.

d. <u>Reservoirs</u>.

(1) Main dam

(a) Length of maximum pool (PMF) - $6500^{\pm}$ feet.

(b) Length of operating pool - No pool behind dam on 26 August 1979. Not applicable.

(c) Length of impounded tailings - $14{,}000^{\pm}$ feet.

(2) Original dam

(a) Length of maximum pool (PMF) - $2500^{\pm}$ feet (including area impounded by railroad embankment across the back of the pond).

(b) Length of operating pool - $1000^{\pm}$ feet.

(c) Length of impounded tailings - $5000^{\pm}$ feet (including area above railroad embankment across the back of the pond).

e. <u>Storage Above Tailings Surface</u>.

(1) Main dam

(a) Top of dam (El. 895.0 feet) - 1951 acre-feet.

(b) Operating pool - No pool behind dam on 26 August 1979. Not applicable.

(c) Spillway A crest (El. 886.3 feet) - 493 acre-feet.

(d) Spillway B crest (El. 890.1 feet) - 925 acre-feet.

(e) Top of intake tower (El. 879.8 feet at level of lower openings) - 100 acre-feet.

(2) Original dam

(a) Top of dam (El. 901.7 feet) - 423 acre-feet.

(b) Operating pool (El. $888^{\pm}$ feet on 25 August 1979) - 18 acre-feet.

f. <u>Reservoir Surface Areas</u>.

(1) Main dam

(a) Top of dam (El. 895.0 feet) - 278 acres.

(b) Operating pool - No pool behind dam on 26 August 1979. Not applicable.

(c) Spillway A crest (El. 886.3 feet) - 88 acres.

(d) Spillway B crest (El. 890.1 feet) - 142 acres.

(e) Top of intake tower (El. 879.8 feet at level of lower openings) - 36 acres.

(2) Original dam

(a) Top of dam (El. 901.7 feet) - 57 acres.

(b) Operating pool (El. 888± feet on 25 August 1979) - 11 acres.

g. <u>Dams</u>.

(1) Main dam

(a) Type - Rockfill and spigoted tailings.

(b) Crest length - 2930± feet.

(c) Height (maximum above steambed) - 134 feet at main dam Station 20+82.

(d) Crest width - 15 to 25 feet.

(e) Side slopes -

- Downstream slope - Variable between 1.25(H) to 1.0(V) and 1.40(H) to 1.0(V).

- Upstream slope - Unknown.

(f) Zoning - The zoning of the main dam is shown on a generalized cross section in a technical article entitled "The Davis Creek Dam" included in Appendix B (page B-2), and also on a cross section presented in a report entitled "Tailings Dam Investigation - St. Joe State Park - Flat River, Missouri" by Sverdrup and Parcel and Associates, Inc. included in Appendix B (page B-32). The zoning consists of a homogeneous rockfill starter dam to El. 797 feet. The rockfill consists of waste rock grading from 2 inches to 28 inches in size. The upstream slope is blanketed with minus 2-inch material overlain by minus 12-millimeter material, referred to as jig chat, from an old tailings pile. Finer lead tailings exist above the jig chat. The zoning of the dam upstream and above the starter dam to about El. 830 feet consists of coarse lead tailings

comprised of fine sand and silt faced with waste rock of the size used in the starter dam. Above El. 830 feet the dam consists of finer lead tailings retained by downstream rockfill zones.

(g) Cutoff - A 270-foot long, 16-foot wide, and 5.5-foot deep trench was excavated to bedrock along the centerline of the rockfill starter dam and was filled with minus 200 mesh tailings.

(2) Original dam

(a) Type - Rockfill and spigoted tailings.

(b) Crest length - 7060± feet.

(c) Height (above downstream toe at maximum section) - 124 feet at original dam Station 26+86.

(d) Crest width - 15 to 50+ feet. (There is no distinct division between the dam and the tailings surface, and the crest is not well defined.)

(e) Side slopes -

- Downstream slope - Variable between 1.0(H) to 1.0(V) and 3.0(H) to 1.0(V).

- Upstream slope - Unknown.

(f) Zoning - No written information was available to indicate the zoning of the original dam and whether a starter dam was constructed or not. From the field inspection it appears that the zoning of the dam consists of sand and silt sized lead tailings faced with rockfill.

(g) Cutoff - No written information was available to indicate that a cutoff was designed or constructed.

h. Spillways.

(1) Main dam

(a) Type -

- Spillway A - Uncontrolled trapezoidal open channel at left abutment.

- Spillway B - Low point in terrain of left abutment hillside upstream of dam.

(b) Control section -

- Spillway A - The control section, which creates a backwater condition in the spillway channel, is located in line with the dam crest at approximately spillway A Station 3+40 at large flows. This is downstream of the spillway crest at the channel inlet (spillway A Station 0+93). It has the following approximate dimensions: 40-foot bottom width, 8-foot depth, 60-foot top width, and approximate side slopes of 1.7(H) to 1.0(V) and 1.3(H) to 1.0(V).

- Spillway B - Located in relatively flat natural channel downstream of the crest dependent on channel flow.

(c) Crest elevation -

- Spillway A - El. 886.3 feet.

- Spillway B - El. 890.1 feet.

(d) Upstream channel -

- Spillway A - 250-foot long open channel of trapezoidal cross section separated from the reservoir at west side of impoundment by a rock dike.

- Spillway B - There is no upstream channel.

(e) Downstream channel -

- Spillway A - Overgrown channel on left abutment hillside parallel to the dam which combines with channel draining the outlet conduits from the intake tower and drains into Shaw Branch. The channel above the outlet conduits is heavily overgrown with grasses, brush, and small trees, and rock outcropping was observed in the channel bottom. The channel below the outlet conduits is eroded through the shale bedrock.

- Spillway B - Neighboring natural drainage to the west of the dam.

(2) Original dam - There is no spillway at this dam for subarea 3. Not applicable.

i. <u>Outlets</u>.

(1) Main dam

(a) Type - Reinforced concrete intake tower with twin 8-foot by 8-foot vertical shafts and twin 8-foot by 8-foot

outlet conduits beneath the dam. A low level intake shaft which feeds into a 30-inch diameter steel outlet pipe which has a closed valve at the outlet end of the pipe makes up the east side of the intake tower.

(b) Length - 310± feet.

(c) Upstream invert - El. 875.9 feet at low level intake, El. 879.8 feet at level of lower openings, El. 885.8 feet at level of upper openings, El. 891.8 feet at top of tower.

(d) Downstream invert at end of outlet conduits - El. 820.0± feet.

(e) Entrance shape - Side openings in intake tower are rectangular and square-edged.

(f) Slope - Estimated to be between zero and 0.2 percent.

(g) Flow - No flow on 26 August 1979 except for minor seepage.

(2) Original dam - The three outlets at this dam are considered nonfunctional. Not applicable.

j. Regulating Outlets. None.

k. Diversion Ditches. None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The only design data found available for the original dam were two design drawings showing details of the two outlet towers and tunnels. These drawings were found in a large set of design drawings of the mill facilities. They were shown to the inspection team during a visit to Team Four Associates in St. Louis, Missouri, on 30 August 1979. One drawing entitled "Federal Mill - Outlet Tower and Culvert for Slime Pond" numbered 1958 and dated 1927 showed the sizes of the #1 intake tower and outlet conduit, and listed one reference elevation at the base of the tower and some coordinates for the location of the tower and outlet. The intake tower was shown as a 5-foot, 6-inch by 4-foot, 3-inch vertical shaft (inside dimensions) with a 42-inch wide inlet opening on one side. The outlet was shown as a 3-foot wide by 4-foot, 8-inch high conduit (inside dimensions) including a 6-inch high arched configuration at the top. A reference of El. 830.00 feet was indicated at the base of the tower. The drawing did not indicate overall dimensions such as the length and slope of the conduit or the height of the tower. The second drawing entitled "Federal Mill - Outlet Tower and Culvert Reinforcing Details" numbered 5344 and dated 23 June 1927 showed the size of the #2 outlet conduit as being a 4-foot wide by 5-foot high tunnel (inside dimensions) and the height of the intake tower as being 60 feet but lacked other overall dimensions. No seepage cutoff collars were shown for the outlet conduits on the drawings. No design drawings or data are known to exist for the original dam embankment itself.

Some design data for the main dam was made available to the inspection team. A copy of a technical article entitled "The Davis Creek Dam" by M. N. Dunlap dated March 1947 and published by the American Institute of Mining and Metallurgical Engineers was obtained both from Team Four Associates during the visit to their office and Mr. John Kennedy, Director of Environmental Control for St. Joe Minerals Corporation. The article contains a description of the design, construction, and function of the main dam and appurtenant structures, and discusses how the tailings disposal operation was carried out. A generalized cross section of the rockfill starter dam with the raised section of tailings faced with rock to about El. 830 feet is contained in the report. Also in the report is a general plan for the original reinforced concrete overflow structure for the main dam which was located at the west end of the starter dam between main dam Station 14+00 and 15+00. This structure no longer exists. The technical article is included in Appendix B (page B-1).

Drawings showing the plan and cross sections of the main dam to its present height were provided to the inspection team by St. Joe Minerals Corporation. The plan is entitled "Davis Creek Dam" and contains spot elevations and a sketch of the intake tower. The cross sections show the zoning of the dam. No dates appear on the drawings, and it is not known whether these drawings are design or construction drawings. The drawings are presented as Figures 1, 2, and 3 in a report entitled "Tailings Dam Investigation - St. Joe State

Park - Flat River, Missouri" by Sverdrup and Parcel and Associates, Inc. of St. Louis, Missouri dated January 1978 and are not presented separately in Appendix B. The report is included in Appendix B and discussed in the next section.

2.2 CONSTRUCTION

No construction records for the original dam were available. Construction of the original dam began in the early 1900's when the St. Joseph Lead Company's Federal Division mill was built in 1906. No written information was available to indicate the zoning of the dam, whether a starter dam was constructed or not, or if a cutoff was constructed.

The technical article entitled "The Davis Creek Dam" presented in Appendix B provides the most information available about the construction of the main dam. The article indicates that construction of the main dam began in July 1942. An initial rockfill starter dam was constructed in the drainage west of the original dam. The article states that the starter dam was 550 feet long with a maximum height of 36 feet at El. 797 feet, and that a cutoff ditch 270 feet long, 16 feet wide, and 5.5 feet deep was excavated to bedrock along the proposed dam's centerline and filled with tailings. The dam was built of waste rock grading from 2 inches to 28 inches in size. The upstream slope was blanketed with layers of material which decreased in particle size in the upstream direction to seal the dam. Minus 2-inch material was dumped over the upstream slope and was subsequently covered by minus 12-millimeter material, referred to as jig chat, from an old tailings pile which in turn was covered by tailings deposited from a pipeline from the mill.

Lead tailings were deposited behind the starter dam, and the dam was subsequently raised with tailings to about El. 830 feet by discharge through a pipeline at many positions along the dam according to the procedure outlined in the technical article. Tailings deposition to about El. 830 feet was in an upstream direction from the dam crest. As the main dam was raised it intersected the original dam at its southwest corner. The steep northern or downstream slope of the tailings was faced with waste rock greater than 2-inch size. A reinforced concrete overflow structure was constructed at the west end of the starter dam between main dam Station 14+00 and 15+00. A plan and a description of its construction are given in the technical article.

In a preliminary report entitled "Geotechnical Report - St. Joe State Park" by Sverdrup and Parcel and Associates, Inc. of St. Louis, Missouri dated 10 January 1977, a description of how the main dam was raised is given. The report states that above El. 830 feet, tailings were discharged upstream of the dam and deposited by gravity flow toward the dam. Rockfill zones were built up on the dam crest to retain the tailings and water. As the dam was raised, the original overflow structure was abandoned, and a reinforced concrete intake tower with twin 8-foot by 8-foot outlet conduits and a low level intake which feeds into a 30-inch diameter steel outlet pipe was constructed to the west between main dam

Station 7+00 and 8+00. It is not known whether the original overflow structure was removed, but most likely it was buried within the dam as the dam was raised.

As a result of the way tailings were deposited into the main dam impoundment, coarse lead tailings consisting of fine sand and silt exist behind the dam to about El. 830 feet, and finer lead tailings probably exist above this elevation. Above the top of the starter dam, the dam was raised by the upstream method of construction. The dumped waste rock in the downstream zone of the dam is in a loose state and is at or near its natural angle of repose on the downstream face.

Answers to questions regarding the original purpose and function, the present condition, and the dimensions of appurtenant structures observed at the damsite were provided by St. Joe Minerals Corporation. This information along with data from three drill holes made into bedrock is included in Appendix B (page B-10). It was obvious from the field inspection that the present intake tower at the main dam was increased in height as the level of the tailings rose. The side openings in the tower were filled with concrete, and new openings at a higher elevation were provided as the tower was raised. No information was available to indicate that seepage cutoff collars were constructed around the conduits beneath the main dam.

The tailings deposition operation ceased after 1965. Between 1972 and 1976, the St. Joe Minerals Corporation undertook a program of removing its mining facilities and salvaging equipment. In the fall of 1976, the State of Missouri obtained the land, including the tailings impoundment, for the St. Joe State Park as a donation from the St. Joe Minerals Corporation. A master plan report for the state park and tailngs impoundment by Team Four Associates and Anselevicius/Rupe/Associates dated May 1978 and entitled "St. Joe State Park Master Plan - Technical Report" was prepared for the State of Missouri.

A preliminary report referred to in Section 2.1 by Sverdrup and Parcel and Associates, Inc. of St. Louis, Missouri dated 10 January 1977 and entitled "Geotechnical Report - St. Joe State Park" indicates that the main dam appeared stable under static conditions although local surface sloughing was noted on the steep downstream slope, and that the original dam had stabilized and no surface sloughing had occurred recently. The report states that the intake tower and outlet conduits, and the spillway at the left abutment of the main dam were in excellent condition. The condition of the tailings impounded by the dam are discussed, and recommendations for development on the tailings are given. Hydrologic aspects of precipitation, drainage, evaporation, transpiration, infiltration, and percolation for the drainage basin are also discussed. This report is included in Appendix B (page B-12).

A report was prepared by J. H. Williams of the Missouri Geological Survey dated 1 March 1977 and entitled "Engineering Geologic Report on the St. Joe State Park Tailings Dam and Environs". The report indicates concern about the possibility of a massive failure of the main dam considering that the tailings are possibly saturated throughout their vertical thick-

ness and are susceptible to liquefaction under earthquake loading, and considering that the upper portion of the dam above the starter dam is only a veneer of rock over the tailings. The report states that the upstream method of construction was used for the main dam after completion of the starter dam and that it is likely that soft tailings lie directly beneath the crest of the dam. Recommendations were made for subsurface exploration and sampling to verify the character of the tailings and the stability of the dam. This report is included in Appendix B (page B-20).

A stability analysis was made for the St. Joe State Park main dam by Sverdrup and Parcel and Associates, Inc. of St. Louis, Missouri. The results of this analysis are contained in a report dated January 1978 and entitled "Tailings Dam Investigation - St. Joe State Park - Flat River, Missouri" for the State of Missouri Department of Natural Resources. The purpose of the study was to investigate the stability of the main dam under seismic conditions. The report indicates that a ground acceleration of 0.14g will cause the silt tailings behind the main dam to liquefy, and that significant settlement may occur due to densification caused by earthquake shaking. Based upon data collected from three borings drilled to bedrock through the tailings and the dam cross section and material parameters presented in the report, it was reported that the dam has a factor of safety against strength failure between 1.10 and 1.20 for a static condition, between 0.95 and 1.05 for a ground acceleration of 0.1g, and between 0.85 and 0.95 for a ground acceleration of 0.2g. The report also indicates that there is a 90 percent probability that ground acceleration of 0.1g to 0.2g will not be exceeded within the next 50 years. The report concludes that the main dam may stand against minor earthquakes (under Modified Mercalli Intensity Scale VI), but that failure may be induced if an earthquake of greater intensity occurs and an adquate dewatering system is not provided. This report is included in Appendix B (page B-24).

2.3 OPERATION

No operating records are known to exist. The technical article entitled "The Davis Creek Dam" presented in Appendix B describes how the tailings were deposited at the main dam and the function of the appurtenant structures. Many of the appurtenant structures which were operational when the tailings dam was active are no longer functional, and most of the operating equipment such as pumps and pipelines was salvaged before the land was given to the state. Tailings disposal ceased after 1965.

The outflow of surface runoff impounded by the original dam for subarea 3, if great enough, would pass over the dam crest low point at original dam Station 33+60. The outflow of surface runoff impounded by the main dam would pass through an uncontrolled vertical intake tower with twin 8-foot by 8-foot outlet conduits, and, if great enough, would also pass through an uncontrolled, open channel spillway, spillway A, located at the left abutment and over a low point in the terrain of the left abutment hillside upstream of the dam, spillway B, into an adjacent drainage.

2.4 EVALUATION

a. Availability. No design or construction records were available for the original dam except for two design drawings of the outlet towers and tunnels. A technical article describing constructon of the main dam and operation of the tailings impoundment was available and is presented in Appendix B. Gectechnical reports concerning the condition of the main dam and the stability of the main dam under seismic conditions were also available and are presented in Appendix B. Information regarding the function and present condition of appurtenant structures at the dam was supplied by St. Joe Minerals Corporation. The master plan for the St. Joe State Park, including the tailings impoundment, was made available, and detailed topographic maps of the state park were provided by the Missouri Department of Natural Resources, Division of Parks and Recreation.

b. Adequacy. The data obtained from available topographic maps and the visual inspections presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses for the original dam and seepage analyses for the main dam comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and the lack of this information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record. The stability analyses available for the main dam are adequate to show that (1) the factors of safety do not meet the requirements of the Guidelines, (2) the dam could be susceptible to liquefaction under certain earthquake loadings, and (3) the stability of the dam is not adequate. Additional stability studies of the main dam should be performed for appropriate loading conditions, including earthquake loads, in conjunction with any evaluations made to increase the stability of the dam and should be made a matter of record. Attention should be given to a more detailed study of the seismicity of the site, the response of the dam, and the seismic parameters of the materials in conjunction with future stability evaluations and recommendations.

c. Validity. Not applicable to the original dam because no design data for the embankment was available. The technical article entitled "The Davis Creek Dam" presented in Appendix B provides a fairly good documentation of the construction of the main dam and the operation of the tailings impoundment; however, detailed dimensioning of the dam is not given, and not all data could be verified by a visual inspection. No quality control records are known to exist. The available stability analyses of the main dam were performed with accepted procedures, and the conclusions of these analyses are considered valid for use as a basis for conclusions concerning the safety of the dam in this report.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. The dam was inspected by two civil engineers from International Engineering Company, Inc. on 25 and 26 August 1979. Mr. Tom Sieve, the park superintendent at the damsite, met with the inspection team on 22 August 1979 to tour the damsite and reservoir area. A visit was made to Mr. Joe Goedde, Program Director for the Missouri Department of Natural Resources, Division of Parks and Recreation, in Jefferson City, Missouri on 24 August 1979 to obtain topographic data for the damsite and the watershed drainage area. Mr. John Kennedy, Director of Environmental Control for St. Joe Minerals Corporation, the previous owner of the dam, also met with one member of the inspection team on 29 August 1979 to provide information about the design, construction, and operation of the impoundment. The impoundment created by St. Joe State Park Dam contains lead tailings. Tailings deposition ceased after 1965. Photographs taken during the inspection are included in this report. The field locations of the photographs are shown on Plate 9.

b. Project Geology. The impoundment watershed is covered by a residual, gray-brown, gravelly silt weathered from dolomite and limestone. The underlying bedrock is mapped as dolomite with shale beds of the Cambrian Age, Bonneterre Formation. Bedrock was exposed in the spillway A channel of the main dam on the left abutment hillside and was observed at the left abutment contact of the initial rockfill starter dam at approximately El. 790 ft. Horizontally bedded shale was observed at the outlet of the conduits passing beneath the main dam from the intake tower. The drainage channel below the outlet conduits (El. 820 feet) and below the point where the spillway A channel joins this drainage is eroded in a stairstep fashion through the shales.

c. Dam. The plan of the main dam is shown on Plate 3A, and the plan of the original dam is shown on Plate 3B. The profile and cross sections of the main and original dams are shown on Plates 4 and 5. The profile of spillway A at the left abutment of the main dam is shown on Plate 6, and a road profile along the left abutment hillside upstream of the main dam which includes cross sections of spillways A and B is shown on Plate 7A. A cross section of spillway C is shown on Plate 7B. Plate 8 shows pertinent dimensions and elevations of the main dam intake tower as determined from field measurements on 25 August 1979.

There is essentially no vegetation on either the original dam face or the main dam face. Some trees were observed to be growing out of the lower portion of the main dam embankment at the left abutment and appeared to be rooted in the foundation. A few small trees were growing on the crest of the starter dam. Scattered weeds and grasses were growing along the crest of both dams, and weeds, grasses, and brush was observed along the upstream slope of the main dam adjacent to the tailings surface. Dense forest and underbrush exists in the drainage of Shaw Branch below the original and main dams. Grasses are growing on a considerable portion of the tailings surface.

No detrimental settlement, depressions, cracks, sinkholes, erosion, piping, or animal burrows were observed in or near either the original or the main dams. Some minor surface erosion and surface ravelling was observed along the downstream slope of the main dam.

No seepage was observed at any point along the toe or downstream face of the original dam. Some seepage was observed at the joints in the twin 8-foot by 8-foot concrete outlet conduits passing beneath the main dam between Stations 7+00 and 8+00. The total seepage into the two conduits and exiting at their outlet was estimated to be about 1 gpm. Seepage was evident around the exterior of the concrete conduit outlet at the toe of the dam. Seepage was observed on both sides and on top of the outlet and was also observed issuing from the exposed bedding planes in the shale adjacent to the outlet on its west side. Marsh grass was growing on both sides of the outlet. All seepage observed was flowing clear. The only other evidence of seepage observed was at the maximum section of the main dam at the toe of the starter dam in the vicinity of Station 21+00. The natural ground, for a width of about 30 feet at the dam toe, was soft and wet, although no seepage was observed at the ground surface. Marsh grass was growing in this area.

The elevation difference between the main dam crest and the tailings surface adjacent to the dam ranged from about 13 to 21 feet. The elevation difference between the main dam crest low point and the level of the lower openings in the intake tower was 15.2 feet. The elevation difference between the dam crest low point and the spillway A crest was 8.7 feet, and the elevation difference between the dam crest low point and the spillway B crest was 4.9 feet. A distinct division between the embankment and the tailings surface at the original dam does not exist in many areas making freeboard difficult to define. Waste rock from the mining operation covers the upstream and downstream faces of the original and main dams and provides slope protection. This rock is similar to the rock grading from 2 inches to 28 inches in size which was used to construct the starter dam for the main embankment. A majority of the rock on the slopes is between 6 inches and 10 inches in size.

No evidence of instability was observed at any of the abutments. The left abutment of the main dam is covered with a shallow layer of gravelly sandy silt overlying bedrock. It was not possible to determine if clearing and stripping of foilage had been done on the abutment or if the overburden had been stripped to bedrock beneath the dam as it was raised up the left abutment. The right abutment of the main dam is actually the southwest corner of the original dam at original dam Station 21+41.

d. Appurtenant Structures.

(1) Main Dam: The primary spillway at the main dam, spillway A, is an uncontrolled open channel of trapezoidal cross section located at the end of the dam at the left abutment. The channel begins about 250 feet upstream of the dam crest, and the slope of this approach section is less than one percent. The upstream channel is separated from the reservoir at the west side of the impoundment by a rock dike.

Downstream of the dam crest, the channel makes a sharp turn to the east and is aligned parallel to the dam on the left abutment hillside. The channel is separated from the dam toe between spillway A Stations 4+00 and 7+00 at the left end of the dam by a rock dike. The centerline of the channel is aligned approximately 150 feet downstream of the dam toe. Just beyond Station 10+00 of the spillway A channel at approximately El. 820 feet, the channel combines with the channel draining the outlet conduits from the intake tower. The channel continues down the left abutment hillside parallel to the dam toe to the natural stream channel of Shaw Branch. The spillway A channel profile and cross sections are shown on Plate 6 and Plates 4A and 7 respectively.

The spillway A channel above the outlet conduits at El. 820 feet is heavily overgrown with grasses, brush, and small trees, and the area just in front of the entrance to the spillway channel at Station 0+93 is occupied by dense brush and trees. The approach section of the channel upstream of the dam is not as overgrown as the rest of the channel. Rock outcropping was observed in the channel bottom just downstream of the dam crest where the channel turns down the left abutment hillside and at other locations farther down the hillside. The depth to bedrock in the approach section of the channel is probably quite shallow. There are no stilling basins or energy dissipators for spillway A.

Spillway B, located about 700 feet upsteam of the main dam crest, is a low point in a road along the left abutment hillside. This low point was probably not intended as a spillway, but it would function as an auxillary spillway prior to dam overtopping. Flood discharge passing over this low point would flow into an adjacent drainage to the west of the dam and would not drain into Shaw Branch. A profile of the road with a cross section of spillway B is shown on Plate 7.

A reinforced concrete outlet structure consisting of an uncontrolled intake tower with twin 8-foot by 8-foot vertical shafts which turn 90 degrees at the bottom of the tower and pass beneath the embankment to exit at the downstream toe exists near the left abutment of the main dam. The 8-foot square outlet conduits pass beneath the embankment between main dam Stations 7+00 and 8+00. On the east side of the intake tower is a third shaft which functioned as a low level intake when the tailings dam was in operation. The shaft feeds into a 30-inch diameter steel outlet pipe which passes beside the outlet conduits. A valve at the outlet end of the pipe is closed. The height of the intake tower above its foundation is about 70 feet, and it has two levels of inlet openings on each side of the tower above the tailings surface. The openings are rectangular, 6 feet wide and 4.5 feet high, and square-edged. The top of the tower is open. Reinforcing steel is exposed at the inlet openings and at the top of the tower; the tower was raised and inlet openings were filled with concrete as the tailings level increased when the dam was active. The outlet conduits are approximately 310 feet long and have an estimated slope between zero and 0.2 percent. The transition between the vertical shafts and the horizontal conduits is a curved surface having a radius of about 8 feet. Pertinent dimensions and elevations of the intake tower are shown on Plate 8.

The intake tower and outlet conduits are in good condition. No flow was passing through the outlet structure on the date of inspection except for some minor seepage which was leaking into the structure through the concrete joints. There are no stilling basins or energy dissipators at the outlet of the conduits; however, a concrete apron does exist at the outlet. The concrete pad, about 15 feet long by 25 feet wide and constructed on bedrock, appeared to be in fairly good condition. The channel downstream of the outlet conduits which combines with the spillway A channel and drains into Shaw Branch is eroded through the shale bedrock.

(2) Original Dam: There is no spillway at the original dam to discharge runoff for subarea 3. A reinforced concrete intake structure with a 24-inch diameter steel pipe passing beneath the north leg of the dam between original dam Station 40+00 and 41+00 is not functional. The outlet pipe which served as a feed line to the mill was closed when operations ceased. Two reinforced concrete intake towers and outlet conduits are located along the west leg of the original dam. The outlet for outlet tower and tunnel #2 was not found during the field inspection; information supplied by St. Joe Minerals Corporation indicates that the outlet was bulkheaded and is buried near the intersection of the original and main dams. The intake tower, open at the top, has an inside dimension of 3.5 feet square and has 8-inch by 3.5-foot square-edged openings on two sides as measured in the field. The outlet for outlet tower and tunnel #1 is located adjacent to an abandoned pumphouse near the toe of the northwest corner of the dam. It was silted to within less than 12 inches from the top of the outlet. The width of the outlet conduit was measured as 3.0 feet. The intake tower was open at the top and had a 3.8-foot wide opening on one side with flashboards. A 12-inch diameter steel pipe within the tower and tunnel exits through this side opening. The pipe was used as an inlet line to the original dam pond. The concrete of both intake towers is in fairly good condition; the concrete at the outlet of tower and tunnel #1 is in poor condition.

A 48-inch diameter steel culvert draining subarea 2 into subarea 3 passes beneath the embankment at the back of the original dam pond at original dam Station 58+80. The culvert is approximately 100 feet long and has a short 36-inch diameter steel pipe section attached to a steel plate at the west or downstream end of the culvert. The inverts at the inlet end, at the transition between the two sections, and at the outlet end based on the topographic maps and field measurements are at El. 905.2$\pm$ feet, El. 904$\pm$ feet, and El. 901.0$\pm$ feet, respectively. The short pipe section would act as a spout to direct flow down into the pond. Nothing exists to dissipate energy at the outlet of the culvert, and considerable erosion of the tailings was observed where the culvert empties into the original dam pond.

A low point in the natural terrain, approximately 350 feet east of the railroad embankment, at original dam Station 54+00, would allow a discharge to flow from subarea 2 into the neighboring drainage north of the dam. This low point has been designated spillway C. A cross section of spillway C is shown on plate 7B.

e. Reservoir Area. No evidence of landsliding was observed in the reservoir area. There are no upstream structures within the watersheds of either the original dam or the main dam that would be subjected to backwater flooding. Most of the watershed consists of undisturbed forest with no evidence of excessive erosion activity. Grasses are growing on a considerable portion of the tailings surface. Erosion was noted in the tailings pond where intermittent drainage channels were developing through the tailings. Over time, sediment will accumulate behind the dam, reducing storage capacity. The sediment is derived from erosion of the tailings as the intermittent drainage channels are established. The tailings impounded by the original and main dams consist of saturated, loose, fine sand and silt that have been deposited by hydraulic methods. The tailings impounded by the original dam are probably more stable than those impounded by the main dam, because the original dam has been inactive for a longer period of time.

f. Downstream Channels. The channel downstream of the main dam which drains the outlet structure and spillway A is eroded through the shale bedrock. The natural downstream channel of Shaw Branch, also known as Davis Creek, below the St. Joe State Park Dam is undeveloped and heavily forested. Shaw Branch drains into Flat River about 6000 feet downstream of the dam at which point the river flows through the town of Flat River.

3.2 EVALUATION

a. Main Dam. This dam has deficiencies that threaten the stability of the embankment. Above the starter dam to about El. 830 feet, the tailings dam is constructed of lead tailings consisting of fine sand and silt that were deposited by gravity flow in an upstream direction from the dam crest. Above El. 830 feet, the dam probably consists of finer lead tailings, because the tailings were discharged upstream of the dam and deposited by gravity flow in a downstream direction toward the dam. Above the starter dam, the embankment was raised by the upstream method of construction. Available information indicates that the water table in the tailings behind the main dam is close to the surface. Because of the gradation of the tailings and the water level within them, this dam could be subject to liquefaction under earthquake loading and must be considered potentially unstable.

Although no tailings have been deposited behind the main dam for many years, minimal consolidation of the tailings has probably taken place, particularly in the zone of finer tailings above about El. 830 feet. Therefore, the downstream rockfill zones could be retaining a material with very low strength.

The main dam is a relatively porous structure above the tailings surface. If the water level were to rise high enough above the tailings surface adjacent to the dam due to flood runoff, there could be significant seepage through the embankment which could adversely affect the stability of the dam.

No major seepage was observed at the main dam. Some seepage was observed around the concrete outlet conduits. Although no slope instability other than minor surface ravelling was observed, the downstream embankment slope is at or near the angle of repose of the rockfill comprising the downstream zone. Seepage analyses are needed for the evaluation of the long-term stability of the dam. This is particularly important because of the relatively thin veneer of rock protecting the downstream slope of the tailngs above the starter dam and because the fine sand and silt tailings could have a low resistance to erosion and piping. Available slope stability analyses indicate that the dam does not meet the stability requirements of the "Recommended Guidelines for Safety Inspection of Dams". The waste rock comprising the upstream slope of the main dam above the tailings surface appears to be adequate erosion protection.

b. Original Dam. This dam has deficiencies that threaten the stability of the embankment. Although the tailings deposit behind the original dam is probably more stable than the deposit behind the main dam because it has been inactive for a longer period of time, this could not be determined by a visual inspection. Therefore, like the main dam, this dam could be subject to liquefaction under earthquake loading. No information was available to indicate how the original dam was constructed. From the field inspection, it appeared that it may have been constructed by the upstream method similar to the main dam above the starter dam. Therefore, like the main dam, the downstream rockfill zones may be effectively retaining a material with very low strength.

No seepage was observed at the original dam, and although no slope instability was observed, the downstream embankment slope is at or near the angle of repose of the rockfill comprising the downstream zone. The long-term stability of the dam can not be evaluated until seepage and stability analyses are performed. The waste rock comprising certain portions of the upstream slope of the original dam above the tailings surface appears to be adequate erosion protection; however, there are many areas where a distinct division between the embankment and tailings surface does not exist which makes freeboard difficult to define. These areas have essentially no erosion protection.

The original dam has no spillway to discharge floodwater from subarea 3, and all structures that could function as outlets are either closed or plugged, making them nonfunctional. Overflow would pass over the dam crest low point at original dam Station 33+60. Any overtopping that might occur as a result of flood runoff could cause erosion of the embankment materials and could threaten the stability of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

No regulating procedures are known to exist for either the original dam or the main dam. Tailings are no longer conveyed to either impoundment. The outflow of surface runoff impounded by the original dam in subarea 3, if great enough, would pass over the dam crest low point at original dam Station 33+60. The outflow of surface runoff impounded by the main dam would pass through an uncontrolled vertical intake tower with twin outlet conduits, and, if great enough, would also pass through an uncontrolled, open channel spillway, spillway A, located at the left abutment and over a low point in the terrain of the left abutment hillside upstream of the dam, spillway B, into an adjacent drainage.

4.2 MAINTENANCE OF DAM

Information available to the inspection team indicates that the dam is not regularly maintained.

4.3 MAINTENANCE OF OPERATING FACILITIES

There are no operating facilities at this dam. Not applicable.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

Information available to the inspection team indicates that there is no warning system for this dam.

4.5 EVALUATION

The behavior of the dam should be monitored periodically to observe any indications of instability, such as cracks in the dam, sloughing, sudden settlement, erosion of the dam or spillways, or an increase in the volume or turbidity of emerging seepage. A maintenance program should be initiated for the dam.

SECTION 5 - HYDRAULIC AND HYDROLOGIC ANALYSES

5.1 EVALUATION OF FEATURES

Hydraulic and hydrologic analyses were made by Sierra Hydrotech of Placerville, California.

a. Design Data. The significant dimensions of the dams, spillways, and outlet structures are presented in Section 1 - Project Information and in the accompanying drawings, Plates 3 through 8. No hydrologic or hydraulic design information is available.

For this evaluation, the watershed drainage areas, stream lengths and slopes, and reservoir areas were obtained from the St. Joe State Park, Mo., May 1976, 1 inch = 1000 feet scale, 10-foot contour topographic map prepared for the Missouri Department of Natural Resources, Division of Parks and Recreation by Western Air Maps, Inc. of Lenexa, Kansas.

The total drainage area of the St. Joe State Park Dam, I.D. No. 30277, is 3176 acres (4.96 square miles). The watershed and drainage boundary are shown on Plate 2. The watershed was divided into the following three separate subareas:

Subarea	Incremental Drainage Area (Acres)
1. Watershed above Main Dam	2771
2. Watershed above Railroad Embankment	333
3. Incremental Area Between the Railroad Embankment and the Original Dam	72

Land use and vegetation patterns in the watershed were determined from field observations and aerial photographs. Soil classifications were obtained from soil survey field sheets prepared by the U.S. Department of Agriculture Soil Conservation Service (SCS). The soil groups for this watershed are classified as Wilderness Cherty Silt Loam, Hildebrecht Silt Loam, and Caneyville Stony Silt Loam, all equivalent to hydrologic soil group C classification, which has a slow rate of water transmission, and Goss Very Cherty Silt Loam, equivalent to hydrologic soil group B classification, which has a moderate rate of water transmission. The tailings have been classified by the SCS as soil group A, which has a high rate of water transmission.

The observed ponding and water table information as well as the antecedent conditions associated with this analysis indicated the necessity of assigning significantly higher curve numbers to tailings than would be used for a hydrologic soil group A classification. The type of land

cover and land use were used to estimate runcff curve numbers (CN) for the antecedent moisture conditions (AMC), which determine the amount of infiltration, retention losses, and net runoff.

The data and assumptions used in the hydrologic and hydraulic analyses for each subarea are individually discussed below. Basin parameters such as lag time, unit hydrograph, probable maximum precipitation, losses, and net runoff for each subarea are presented in Appendix A.

Subarea 1 - Watershed above Main Dam

The drainage area of this subarea is 2771 acres (4.33 square miles). The watershed was divided into the following types of land use and vegetal cover:

Type of Cover	Approximate Percent of Watershed
Water	2
Tailings	26
Grassland (Hydrologic Soil Group C)	2
Woodland (Hydrologic Soil Group B)	21
Woodland (Hydrologic Soil Group C)	49

The estimated runoff curve numbers (CN) weighted according to the above land cover distribution are CN 63 for the antecedent moisture condition (AMC) II condition and CN 80 for the AMC III condition.

There are three means for flood discharge at the main dam impoundment. A reinforced concrete outlet structure consisting of a vertical intake tower with twin 8-foot by 8-foot outlet conduits that pass beneath the dam is located between Stations 7+00 and 8+00 of the main dam near the left abutment. A trapezoidal spillway channel, spillway A, is located at the left abutment, and a low point in the terrain of the left abutment hillside upstream of the dam would function as an auxillary spillway, spillway B, allowing flood discharge to flow into an adjacent drainage. The dam and spillway profile and cross section data was developed from the St. Joe State Park, Mo., May 1976, 1 inch = 100 feet scale, 2-foot contour topographic maps and from field measurements made on 25 August 1979. This data is presented on Plates 3A, 4A, 4B, 5, 6, and 7A. The intake tower and twin 8-foot by 8-foot outlet conduit data was obtained from field measurements made on 25 August 1979 and is presented on Plate 8. The outlet and spillways are individually discussed below:

(1) Reinforced Concrete Intake Tower with Twin 8-foot by 8-foot Outlet Conduits: The conduits which pass beneath the dam are approximately 310 feet $\pm$ long. The inverts at the upstream and outlet ends are at El. 820.5$\pm$ feet and El. 820.0$\pm$ feet, respectively. The pertinent dimensions and elevations of the intake tower as determined from field measurements and the topographic maps are shown on Plate 8.

Several possible flow conditions can exist, depending on the water surface elevation at the intake tower. The discharge rating curve for the 8-foot by 8-foot conduits was calculated using a Manning's "n" of 0.017; however, inlet capacity controlled within the range of water surface elevations up to and including the maximum pool (PMF) level. Inlet capacity was calculated in the following ways:

- Weir flow condition when the reservoir water surface is below the top of the inlet opening (El. 884.3 feet for the lower openings and El. 890.3 feet for the upper openings). A weir discharge coefficient of C = 3.4 was used.

- Orifice flow condition when the reservoir water surface submerges the inlet opening.

- Broad crested weir flow condition when the reservoir water surface is above the opening at the top of the intake tower (El. 891.8 feet). A weir discharge coefficient of C = 2.7 was used.

The intake tower will operate as a weir, as a weir and an orifice, or as an orifice and a broad crested weir depending upon the reservoir water surface elevation.

(2) Spillways A and B: The crest of the spillway channel located at the left abutment of the main dam is at El. 886.3 feet, and the elevation of the low point on the left abutment hillside upstream of the dam that would function as the crest of an auxillary spillway is El. 890.1 feet according to spot elevations on the topographic maps. Both spillway channels have relatively flat slopes in their upper reaches, and consequently there is a substantial backwater control of spillway capacity. The spillway discharge rating curves were calculated using a backwater analysis and a Manning's "n" of 0.040. The spillway A channel becomes steep and has different hydraulic characteristics downstream from its control section at the dam crest. This downstream reach does not control discharge.

The minimum dam crest elevation is located approximately at main dam Station 3+30 adjacent to the spillway A channel and is El. 895.0 feet. Computations of the discharge rating curve for flows over the main dam crest were made by using the weir flow formula with a weir coefficient of C = 2.7 for the dam crest. The combined discharge rating curve data for flows through the outlet structure conduits, in the spillways, and over the dam crest is shown in Appendix A, under the input data listing as Y4 and Y5 cards, and also in the computer printout.

The reservoir area-capacity curve data is shown in Appendix A. The capacities shown, as computed by the Conic Method in the computer program, are the active capacities at the given elevations above the tailings. Storage of flood runoff that might be provided by the several small peripheral ponds around the tailings deposit is not significant for large floods and was ignored in the analyses.

Subarea 2 - Watershed above Railroad Embankment

The drainage area of this subarea is 333 acres (0.52 square miles). The watershed was divided into the following types of land use and vegetal cover:

Type of Cover	Approximate Percent of Watershed
Tailings	33
Woodland (Hydrologic Soil Group B)	54
Woodland (Hydrologic Soil Group C)	13

The estimated runoff curve numbers (CN) weighted according to the above land cover distribution are CN 57 for the antecedent moisture condition (AMC) II condition and CN 75 for the AMC III condition.

There are two means for flood discharge at the railroad embankment. The railroad embankment is actually the back side of the original dam impoundment between Station 55+00 and 70+56 of the original dam. This embankment would prevent flood runoff from flowing directly into the original dam pond. A 48-inch diameter steel culvert with a steel plate and 36-inch diameter pipe section attached at the west or downstream end passes beneath the railroad embankment at original dam Section 58+80. A low point in the terrain approximately 350 feet east or upstream of original dam Station 54+00 would function as a spillway, referred to as "spillway C" in this report, allowing flood discharge to flow northward down a neighboring drainage channel. Flood discharge over this low point leaves the basin and would not enter the original dam pond (subarea 3). Discharges through the culvert and over the railroad embankment become inflows to the original dam. The railroad embankment profile and topographic data for spillway C were obtained from the St. Joe State Park, Mo., May 1976, 1 inch = 100 feet scale, 2-foot contour topographic maps. The embankment profile is presented on Plate 4E, and a cross section of spillway C is shown on Plate 7B. Profile data for the 48-inch/36-inch diameter culvert was obtained from field measurements made on 26 August 1979. The culvert and spillway C are individually discussed below:

(1) 48-inch/36-inch Diameter Steel Culvert: The culvert which passes beneath the railroad embankment is approximately 100 feet long. The 36-inch diameter section is a short pipe attached to a steel plate at the west end of the culvert at a much steeper slope than the 48-inch diameter section. The inverts at the inlet end, at the transition between the two sections, and at the outlet end are at El. 905.2± feet, El. 904± feet, and El. 901.0± feet, respectively.

Depending on the inlet water surface elevation, flow in the culvert under the railroad embankment may be controlled either by entrance conditions or by the culvert capacity and may be under partial flow or full flow conditions. The culvert may function as a 48-inch diameter pipe flowing partially full or a combination of a 48-inch diameter pipe flowing full with a 36-inch diameter orifice or a 36-inch diameter short

tube at its outlet end. A discharge coefficient of C = 0.72 was used when the entrance controls and partial flow occurs. A discharge coefficient of C = 0.82 was used when the flow in the 36-inch diameter pipe is hydraulically short, and a discharge coefficient of C = 0.60 was used for an orifice flow condition. A loss coefficient of the pipe equivalent to a Manning's "n" of 0.015 was used.

(2) Spillway C: A low point in the natural terrain approximately 350 feet east of the railroad embankment at original dam Station 54+00 would allow flood discharge to flow from subarea 2 into the neighboring drainage north of the dam. This low point that would function as a spillway for this subarea, designated as spillway C, is at El. 911.0± feet. Flood discharge would pass through spillway C prior to overtopping the railroad embankment into the original dam pond. Flow over this low point was calculated as flow over a broad crested weir with a weir discharge coefficient of C = 2.7.

The minimum embankment crest elevation between original dam Station 55+00 and 70+56 at which overtopping into the original dam pond could occur is located between Station 55+00 and 57+15 and is El. 914 feet. Computations of the discharge rating curve for flows over the railroad embankment into the original dam pond were made by using the weir flow formula with a weir coefficient of C = 2.7 for the embankment crest. The combined discharge rating curve for flows through the culvert, in spillway C, and over the embankment is shown in Appendix A, under the input data listing on Y4 and Y5 cards, and also in the computer printout.

The area-capacity curve date is shown in Appendix A. The capacities shown, as computed by the Conic Method in the computer program, are the active capacities at the given elevations above the tailings.

Subarea 3 - Incremental Area Between the Railroad Embankment and the Original Dam

The drainage area of this subarea is 72 acres (0.11 square miles). The watershed was divided into the following types of land use:

Type of Cover	Approximate Percent of Watershed
Water	13
Tailings	87

The estimated runoff curve numbers (CN) weighted according to the above land cover distribution are CN 80 for the antecedent moisture condition (AMC) II condition and CN 91 for the AMC III condition.

No spillway is present at the original dam for subarea 3. The intake structure with a 24-inch diameter steel pipe at the north leg of the dam between original dam Station 40+00 and 41+00, which served as the feed line to the mill, was closed when operations ceased. The reinforced concrete vertical outlet tower and tunnel #2 located at the west leg of the

original dam near its intersection with the main dam is bulkheaded at the outlet which is buried near the intersection of the two dams according to information supplied by St. Joe Minerals Corporation. The reinforced concrete vertical outlet tower and tunnel #1 located at the northwest corner of the dam between original dam Station 32+00 and 33+00 was almost completely plugged with silt at its outlet. For these analyses, none of the outlets were considered to be functional. The original dam profile and cross section data was developed from the St. Joe State Park, Mo., May 1976, 1 inch = 100 feet scale, 2-foot contour topographic maps. This data is presented on Plates 3B, 4C, 4D, 4E, and 5.

The minimum dam crest elevation is located at original dam Station 33+60 and is El. 901.7 feet. Computations of the discharge rating curve for flows over the original dam crest were made by using the weir flow formula with a weir coefficient of C = 2.7 for the dam crest. The discharge rating curve for flows over the dam crest is shown in Appendix A, under the input data listing as Y4 and Y5 cards, and also in the computer printout.

The reservoir area-capacity curve data is shown in Appendix A. The capacities shown, as computed by the Conic Method in the computer program, are the active capacities at the given elevations above the tailings.

b. Experience Data. Information about precipitation at the damsite is given in a preliminary report entitled "Geotechnical Report - St. Joe State Park" by Sverdrup and Parcel and Associates, Inc. of St. Louis, Missouri. The report states that mean annual precipitation at the site is about 42 inches, and that records for Farmington indicate that average monthly maximum precipitation which occurs in May is 4.97 inches and minimum precipitation which occurs in December is 2.43 inches. The report, which is included in Appendix B, also describes other hydrologic aspects of the drainage basin including drainage, evaporation, transpiration, infiltration, and percolation.

Rainfall, runoff, or other experience data from measurements at the damsite itself are not available. There is no evidence of historic overtopping of either the main dam, the railroad embankment, or the original dam.

c. Visual Observations. The twin 8-foot by 8-foot outlet conduits under the main dam are open and functional, and the open channel spillway is located at the left abutment of the dam. The outlet conduit connecting outlet tower #1 under the original dam is plugged with silt, and the other two outlets are closed off. Specific information on the visual observations is presented in Section 3 - Visual Inspection.

d. Overtopping Potential. The 100-year flood, probable maximum flood (PMF), and floods expressed as percentages of the PMF were individually computed for each subarea and routed through each reservoir. The PMF is defined as the hypothetical flood event that would result from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible at a particular location or region. A 24-hour probable maximum precipitation (PMP) was used in the

computations for the PMF inflow for the railroad embankment and the original dam. The main dam PMF analyses utilized a 48-hour PMP. The Modified Puls method of spillway routing was employed.

(1) Main Dam: For all cases of the outlet and spillway flood routing, the initial level of the reservoir surface was set at El. 879.8 feet, the level of the lower inlet openings of the intake tower. Flow in the spillway A channel at the left abutment would begin when the water surface reached the spillway crest El. 886.3 feet. Flow over spillway B on the left abutment hillside would begin when the water surface reached El. 890.1 feet. Dam overtopping was considered to start when the reservoir water surface exceeded El. 895.0 feet. It was assumed that the spillway-embankment section would not change due to erosion as the flood discharge occurs; therefore, the combined discharge rating curve for flows through the outlet structure, in the spillways, and over the dam crest is constant throughout the period of flood discharge.

Results of the overtopping analyses indicate that the intake tower with twin 8-foot by 8-foot outlet conduits is able to pass the 100-year flood without the reservoir reaching the spillway A crest. The studies also indicate that the intake tower and spillways can pass about 83 percent of the PMF without overtopping the embankment. At 83 percent of the PMF, the combined peak outflow from the main dam is 11,550 cfs, with a flow depth of 7.9 feet and a flow velocity of about 7.2 feet per second at the spillway A section at the left abutment. Velocities in the channel downstream of the crest would be greater.

A major consideration in evaluating the safety of the main dam is assessing the potential for overtopping and the subsequent failure of the embankment as the result of erosion. Erosion from flood discharge over spillway B into the adjacent drainage will not endanger the main dam. The spillway A channel at the left abutment of the dam is constructed on top of or near bedrock as evidenced by field observations of rock outcroppings in the spillway channel and based on information provided in a preliminary geotechnical report of the St. Joe State Park by Sverdrup and Parcel and Associates, Inc. of St. Louis, Missouri (Appendix B). Since spillway A is composed of shallow overburden overlying bedrock, high velocity discharges through the spillway may not lead to significant erosion of the spillway and the effects of significant erosion may not occur until dam overtopping begins. Based on the Corps of Engineers Manual EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", the maximum permissible velocity for the materials found in the spillway A channel is about 10 feet per second. Using this as a criterion, the spillway control section can pass the PMF without significant erosion. Overtopping would occur immediately adjacent to the spillway A channel at the left end of the dam at 83 percent of the PMF. Thus, a reservoir water surface level exceeding El. 895.0 feet behind the main dam is considered to produce the effects of significant erosion of the embankment.

The results of the overtopping analyses for the main dam are reported in Appendix A and summarized on the following page:

Flood	Peak Inflow (cfs)	Outlet Structure Peak Outflow (cfs)	Spillway A Peak Outflow (cfs)	Spillway B Peak Outflow (cfs)	Max. Res. W.S. Elev. (ft)	Spillway A Flow Depth (ft)	Spillway A Flow Velocity (ft/sec)	Duration Overtopped (hrs)
50% PMF	8647	3480	2300	307	892.6	5.7	5.8	-
80% PMF	13836	4440	4709	1820	894.8	7.7	7.1	-
90% PMF	15565	4700	5441	2850	895.3*	8.2	7.4	1.5
PMF	17295	4800	6300	3831	895.7*	8.5	7.6	2.0

* Dam overtopped (Minimum dam crest El. 895.0 feet).

Note: Reservoir water surface elevations include the velocity heads corresponding to the velocities computed at the spillway A inlet section.

(2) Railroad Embankment: Flood discharges passing through the culvert beneath the railroad embankment and overtopping the embankment become inflows to the original dam pond. For all cases of the culvert and spillway flood routing above the railroad embankment, the analyses were done using an initially empty impoundment with a bottom at El. 905.2 feet. The invert elevation at the inlet end of the 48-inch diameter culvert is El. 905.2 feet and corresponds to this initial condition. Flow over the low spot east of the railroad embankment at original dam Station 54+00, spillway C, would begin when the water surface reached El. 911.0± feet. Embankment overtopping into the original dam pond was considered to start when the reservoir water surface exceeded El. 914 feet. It was assumed that the spillway-embankment section would not change due to erosion as the flood discharge occurs; therefore, the combined discharge rating curve for flows through the culvert, in the spillway, and over the embankment is constant throughout the period of flood discharge.

Results of the overtopping analyses indicate that the culvert is able to pass the 100-year flood without the water surface reaching the spillway level. The studies also indicate that the culvert and spillway can pass about 64 percent of the PMF without overtopping the embankment. At 64 percent of the PMF, the peak outflow from the railroad embankment into the original dam pond is 125 cfs, and the peak outflow through spillway C into the neighboring drainage is 1451 cfs, with a flow depth of 2.5 feet and a flow velocity of about 5.8 feet per second. High velocities such as those at 64 percent PMF peak outflow could cause significant erosion of the spillway channel.

A major consideration in evaluating the safety of the original dam is assessing the potential for the overtopping and the subsequent failure of the railroad embankment as the result of erosion. Since the low point east of the railroad embankment at original dam Station 54+00, spillway C, is composed of erodible materials, high velocity discharges through this area could lead to significant erosion. Based on the Corps of Engineers Manual EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", the maximum permissible velocity for the materials found in the spillway C section is estimated to be about four feet per second. Using this as a criterion and based on studies at 33 percent and 40 percent of the PMF, it is estimated that spillway C can pass about 35 percent of the PMF without significant erosion. The 35 percent PMF routed outflow through spillway C is 355 cfs, with a flow depth of 1.6 feet. The spillway would experience velocities in excess of six feet per second during PMF conditions; however, erosion of the spillway channel will not endanger the railroad embankment. Overtopping, which would occur between original dam Station 55+00 and 57+15 at 64 percent of the PMF, is considered to produce significant erosion of the embankment. Thus, a water surface level exceeding El. 914 feet behind the railroad embankment is considered to produce the effects of embankment failure.

The results of the overtopping analyses for the railroad embankment are reported in Appendix A and summarized on the following page:

Flood	Peak Inflow (cfs)	Spillway C Peak Outflow (cfs)	Peak Outflow to Original Dam Pond (cfs)	Max. Res. W.S. Elev. (ft)	Spillway C Flow Depth (ft)	Spillway C Flow Velocity (ft/sec)	Duration Spillway C Vel. over 4.0 ft/sec (hr)
33% PMF	1110	290	114	912.7	1.5	3.8	-
40% PMF	1346	524	116	913.1	1.9*	4.6*	2.8
50% PMF	1682	913	120	913.5	2.2*	5.2*	3.5
60% PMF	2018	1315	123	913.9	2.4*	5.6*	4.0
70% PMF	2355	1666	175	914.1**	2.6*	6.0*	4.5
PMF	3364	2468	496	914.7**	3.0*	6.6*	6.0

* These flow depths and velocities are considered to produce the effects of significant erosion.

** Railroad embankment overtopped (Minimum embankment crest El. 914 feet). Overtopping flows are inflows to the original dam pond.

Note: Reservoir water surface elevations include the velocity heads corresponding to the velocities computed at the spillway control section.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Conditions that may adversely affect the structural stability of the dam are discussed in Section 3.

b. Design and Construction Data. No design or construction data pertaining to the structural stability of either the original dam or the main dam were available. Seepage and stability analyses for the original dam and seepage analyses for the main dam comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and the lack of this information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record. Stability analyses for the main dam, including analyses for seismic conditions, were performed for the State of Missouri by Sverdrup and Parcel and Associates, Inc. of St. Louis, Missouri. The results of these analyses are presented in a report entitled "Tailings Dam Investigation - St. Joe State Park - Flat River, Missouri" dated January 1978 which is included in Appendix B. The stability analyses are adequate to show that (1) the factors of safety do not meet the requirements of the Guidelines, (2) the dam could be susceptible to liquefaction under certain earthquake loadings, and (3) the stability of the main dam is not adequate. Additional stability studies of the main dam should be performed for appropriate loading conditions, including earthquake loads, in conjunction with any evaluations made to increase the stability of the dam, and should be made a matter of record. Attention should be given to a more detailed study of the seismicity of the site, the response of the dam, and the seismic parameters of the materials in conjunction with future stability evaluations and recommendations.

c. Operating Records. Many of the appurtenant structures which were operational when the tailings dam was active are no longer functional, and most of the operating equipment was salvaged. No appurtenant structures requiring operation exist at the dam, and no records are known to exist.

d. Post-Construction Changes. No post-construction changes related to the structural stability of the dam were apparent.

e. Seismic Stability. The St. Joe State Park Dam is located in Seismic Zone 2, as defined in the Uniform Building Code. There is a high potential for liquefaction at the dam where the embankment and impounded materials consist of loose, saturated fine sand and silt tailings. Slides and slope failures could occur from liquefaction of the tailings where only a relatively thin zone of rockfill protects the downstream face of the tailings. Some crest settlement and ravelling of the embankment rockfill could occur during seismic shaking, because the rockfill is in a loose state and is at or near its natural angle of

repose on the downstream face. Settlement of the tailings themselves could occur due to densification induced by seismic shaking. The seismic stability and liquefaction potential of the main dam is evaluated in the report by Sverdrup and Parcel and Associates, Inc. presented in Appendix B.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety.

(1) Main Dam: The St. Joe State Park main dam has several deficiencies that should be corrected: (1) Above the starter dam, the embankment was raised by an upstream construction method. From the top of the starter dam to about El. 830 feet, the dam consists of fine sand and silt sized lead tailings hydraulically deposited in an upstream direction from the dam crest and faced with rockfill. Above El. 830 feet, the dam consists of finer tailings, resulting from deposition in a downstream direction toward the dam, retained by rockfill zones built up on the crest. The main dam consists of and retains loose, saturated fine sand and silt tailings, and should be considered potentially unstable, particularly when subjected to earthquake loads. (2) Seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and they should be performed and made a matter of record. (3) The stability analyses available for the main dam are adequate to show that (a) the factors of safety do not meet the requirements of the Guidelines, (b) the dam could be susceptible to liquefaction under certain earthquake loadings, and (c) the stability of the dam is not adequate. (4) The discharge capacity of the outlet structure and spillways was computed to be adequate to pass about 83 percent of the Probable Maximum Flood (PMF) without overtopping the embankment and without significant erosion of spillway A or the embankment. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. The "Recommended Guidelines for Safety Inspection of Dams" specifies that the spillway design flood for this dam should be the PMF. Although the hydrologic analysis shows the main dam capable of passing 83 percent of the PMF without overtopping, there could be significant seepage through the embankment when the water level rises high enough above the tailings level adjacent to the dam, because the embankment is a relatively porous structure above the tailings surface. This seepage could adversely affect the stability of the dam. Also, when the reservoir water surface level reaches about El. 894 feet, overtopping of the ridge of the left abutment hillside between spillway B and the dam crest would occur. Flood runoff would pass over the left abutment into the adjacent drainage west of the dam.

(2) Original Dam: The St. Joe State Park original dam has several deficiencies that should be corrected: (1) The original dam, like the main dam, retains fine sand and silt tailings, and although the tailings behind the original dam are probably more stable than those behind the main dam, no data was available to substantiate this. Also, no information was available to indicate how the original dam was constructed. Until appropriate analyses have been done to show otherwise, the original dam, like the main dam, should be considered potentially unstable when subjected to earthquake loads. (2) Seepage and stability

analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and they should be performed and made a matter of record. (3) The original dam has no spillway to remove storm runoff from subarea 3, and all structures that could function as outlets are either closed or plugged making them nonfunctional. It was computed that the original dam can retain about 43 percent of the PMF without overtopping. The "Recommended Guidelines for Safety Inspection of Dams" specifies that the spillway design flood for this dam should be the PMF. Also, the discharge capacity of the 48-inch diameter culvert beneath the railroad embankment across the back of the pond and the low point in the natural terrain, spillway C, which drains into a neighboring drainage channel, was computed to be adequate to pass about 64 percent of the PMF without overtopping the railroad embankment into the original dam pond.

b. Adequacy of Information. No design or construction data were available for the original dam except for two design drawings of the outlet towers and tunnels which gave incomplete information. A technical article describing construction of the main dam and operation of the tailings impoundment was available and is presented in Appendix B. Seepage and stability analyses for the original dam and seepage analyses for the main dam comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and the lack of this data is considered a deficiency. The stability analyses available for the main dam, the results of which are presented in a report entitled "Tailings Dam Investigation - St. Joe State Park - Flat River, Missouri" by Sverdrup and Parcel and Associates, Inc. of St. Louis, Missouri and included in Appendix B, are adequate to show that (1) the factors of safety do not meet the requirements of the Guidelines, (2) the dam could be susceptible to liquefaction under certain earthquake loadings, and (3) the stability of the dam is not adequate.

The data obtained from available topographic maps and the visual inspections presented herein are considered adequate to support the conclusions of this report. In addition to USGS Flat River, Mo., 1958, and Farmington, Mo., 1964, 7.5 minute series, 1:24,000 scale, topographic quadrangles with contour intervals of 20 feet, detailed topographic maps of the state park were available. Hydrologic analyses were based on data developed from field measurements made on the date of inspection and from the St. Joe State Park, Mo., May 1976, 1 inch = 1000 feet scale, 10-foot contour, and 1 inch = 100 feet scale, 2-foot contour topographic maps prepared for the Missouri Department of Natural Resources, Division of Parks and Recreation by Western Air Maps, Inc. of Lenexa, Kansas. Elevations of appurtenant structures described in this report and shown on the plates were obtained either directly from the topographic maps or by hand level measurements during the inspection and referencing to topographic contours and spot elevations on the topographic maps. The available topographic data was considered to be adequate such that a survey of the dam was not required. The data described above is considered to be adequate for the Phase I inspection.

c. Urgency.

(1) Main Dam: The Phase I inspection indicated apparent deficiencies in the condition of the main dam. Seepage analyses, measures to increase the spillway capacity and/or freeboard of the dam to safely pass the PMF, and an evaluation to determine how the stability of the dam can be increased to meet the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be given priority.

(2) Original Dam: The Phase I inspection indicated apparent deficiencies in the condition of the original dam. Seepage and stability analyses, and measures to increase the storage capacity of the dam to safely retain the PMF, or to provide an outlet or spillway with adequate erosion protection to safely pass the PMF should be given priority.

d. Necessity for Phase II. The Phase I investigation raises serious questions relating to the stability and safety of the main and original dams, and additional investigations are recommended as outlined in Section 7.2.a (1), (2) and (3), and 7.2.b (1), (3), (4) and (5). However, no Phase II investigation is required.

7.2 REMEDIAL MEASURES

The following remedial measures are recommended:

a. Main Dam.

(1) Spillways: The discharge capacity of the outlet structure and spillways was computed to be adequate to pass about 83 percent of the PMF without overtopping the embankment and without significant erosion of spillway A or the embankment. To comply with the "Recommended Guidelines for Safety Inspection of Dams" for a dam of this size and hazard potential, the capacity of spillway A should be increased and/or freeboard increased so that the PMF can be passed without overtopping the dam crest and without significant erosion of spillway A or the embankment.

Freeboard would have to be increased very little and would only have to be increased at the left end of the dam between the spillway A channel and main dam Station 6+43 to meet this requirement. If additional freeboard is provided to meet the PMF requirement, it is recommended that this freeboard also be provided in the area along the east side of the approach section of the spillway A channel between the channel entrance and the dam crest. This would keep the spillway channel upstream of the dam separated from the impoundment during periods of large flood runoff. It is also recommended that large rock be placed at the entrance to the spillway A channel for erosion protection and that the dense brush and trees growing in front of the channel entrance be cleared so that flow into the spillway channel is unobstructed.

Additional freeboard should also be provided along the ridge of the left abutment hillside between spillway B and the dam crest. This will pre-

vent flows in spillways A and B from combining during large flood runoffs and passing over the ridge of the abutment into the adjacent drainage west of the dam. An evaluation should be made of the effects of flood runoff which would pass through spillway B into the adjacent drainage west of the dam. The results of this evaluation should determine whether this low point in the terrain of the left abutment hillside should be allowed to function as a spillway or should be filled in to prevent flood runoff from entering the adjacent drainage. Elimination of spillway B would necessitate a re-evaluation of the hydraulic and hydrologic analyses of subarea 1.

(2) Seepage Analyses: Seepage analyses should be performed by a professional engineer experienced in the design and construction of tailings dams. The embankment is a relatively porous structure above the tailings surface. If the water level were to rise high enough above the tailings surface adjacent to the dam, there could be significant seepage through the embankment which could adversely affect the stability of the dam. Also, above the crest of the starter dam, a relatively thin veneer of rock is all that is protecting the downstream slope of the tailings, and the fine sand and silt tailings could have a low resistance to erosion and piping. If the water level were to rise high enough behind the dam, seepage through the tailings could cause piping of tailings through the thin downstream rockfill zone which could adversely affect the stability of the dam. Included in these analyses, therefore, seepage computations should be performed with the reservoir water surface set at the top of the dam, or at the maximum pool (PMF) level if freeboard will be increased so that the dam will pass the PMF without overtopping. Remedial measures to the main dam should be based on the results of the seepage studies and should be done under the direction of a professional engineer experienced in tailings dam design and construction.

(3) Stability Analyses: An evaluation should be made to determine feasible and economical measures to increase the stability of the dam to meet the requirements of the "Recommended Guidelines for Safety Inspection of Dams". Additional stability studies of the main dam should be performed by a professional engineer experienced in the design and construction of tailings dams in conjunction with this evaluation. Attention should be given to a more detailed study of the seismicity of the site, the response of the dam, and the seismic parameters of the materials in conjunction with additional stability evaluations and recommendations. Stability criteria which will dictate the feasibility and economics of increasing the stability of the dam is dependent upon an accurate evaluation of the seismicity of the site. Remedial measures to the main dam should be based on the results of this evaluation and additional stability studies and should be done under the direction of a professional engineer experienced in tailings dam design and construction.

(4) Inspection and Maintenance Program: An inspection and maintenance program should be initiated. Periodic inspections should be made by qualified personnel to observe the performance of the dam, outlet structure, and spillways. Observations should include indications of instability, such as cracks in the embankment, sloughing, erosion,

sudden settlement, or an increase in the volume or turbidity of seepage. Records of these inspections should be maintained, and all maintenance and remedial measures made to the dam, outlet structure, and spillways should be documented.

b. Original Dam.

(1) Overflow Provisions: The existing original dam was computed to be capable of retaining about 43 percent of the PMF without overtopping at its minimum dam crest El. 901.7 feet at Station 33+60. To comply with the "Recommended Guidelines for Safety Inspection of Dams" for a dam of this size and hazard potential, freeboard should be increased to provide greater storage capacity so that the dam is capable of safely retaining the PMF, or an outlet or a spillway should be provided so that the PMF can be passed without overtopping the dam crest and without significant erosion of the spillway or embankment.

Several possible alternatives exist to satisfy the PMF requirement. Outlet tower and tunnel #1 can be cleaned out to provide the original dam with a functional outlet. Adequate erosion protection should be provided at the inlet to the intake tower and at the outlet end of the outlet conduit to prevent future erosion and siltation. Lowering of the inlet opening of the intake tower and/or removal of flashboards should be investigated since the estimated level at the top of the flashboards covering the inlet opening at the time of inspection was El. 901.0± feet, less than a foot below the minimum dam crest (Photograph 14). If not buried too deeply in the dam, the outlet of outlet tower and tunnel #2 could be uncovered, and the bulkheaded outlet could be opened to provide the dam with another functional outlet. Adequate erosion protection should be provided at the inlet to the intake tower and at the outlet end of the outlet conduit to prevent erosion and siltation. If either outlet tower and tunnel is made functional so that the dam can safely pass the PMF without overtopping, its structural integrity should be verified.

Another possible alternative is to cut a channel through the embankment separating the original dam impoundment, subarea 3, and the main dam impoundment, allowing flood runoff that would otherwise have to be retained or passed by the original dam to flow into subarea 1 and through the outlet structure and spillways of the main dam. This, of course, would change the hydrologic characteristics of subarea 1 requiring a re-evaluation of the hydraulic and hydrologic analyses and may require additional capacity of spillway A and/or freeboard at the main dam. Adequate erosion protection should be provided in this channel joining the two impoundments.

An increase in freeboard can be provided as another alternative so that the dam is capable of safely retaining the PMF without overtopping. An increase in freeboard must be considered in seepage and stability analyses as described in Section 7.2.b.(3).

Any one or a combination of these remedial measures may be taken so that the original dam is capable of safely retaining or passing the PMF without overtopping and without significant erosion. An evaluation should be made to determine which one or combination of measures will best meet the requirements. Additional hydraulic and hydrologic investigations are necessary to make this evaluation. These investigations and remedial measures to the original dam based on these investigations should be done under the direction of a professional engineer experienced in the design and construction of tailings dams.

(2) 48-inch/36-inch Diameter Culvert Erosion Protection: Remedial work should be addressed to providing erosion protection at the inlet and outlet ends of the culvert which passes beneath the railroad embankment along the back of the original dam pond at original dam Station 58+80. The erosion protection should be adequate to prevent erosion of the tailings and siltation at the inlet and undermining of the outlet.

(3) Spillway C: An evaluation should be made of the effects of flood runoff which would pass over the low point in the natural terrain, spillway C, into the neighboring drainage north of the dam and avoid entering the original dam pond. The results of this evaluation should determine whether this low point east of the railroad embankment at original dam Station 54+00 should be allowed to function as a spillway or should be filled in to prevent flood runoff from entering the neighboring drainage. Elimination of spillway C would necessitate a re-evaluation of the hydraulic and hydrologic analyses of subareas 2 and 3.

(4) Railroad Embankment: The discharge capacity of the culvert and spillway C was computed to be adequate to pass about 64 percent of the PMF without overtopping the railroad embankment into the original dam pond. Additional freeboard should be provided along the railroad embankment to prevent overtopping and subsequent failure by erosion which might cause a sudden release of water into the original dam pond and overtopping of the original dam. An alternative to this would be to increase the capacity of spillway C if it is determined that this low point upstream of the railroad embankment can be utilized as a spillway to discharge flood runoff into the neighboring drainage north of the dam. Adequate erosion protection should be provided in the spillway C channel, especially in the areas where erosion of the spillway could extend to the original dam. Another alternative would be to remove a portion of the railroad embankment across the back of the original dam pond to eliminate the storage effect of the embankment above the original dam. Adequate erosion protection should be provided in any channel cut through the railroad embankment to prevent the deposit of eroded materials into the original dam pond. A re-evaluation of the hydraulic and hydrologic analyses of subareas 2 and 3 should be done in conjunction with an evaluation of the above alternatives. These investigations and remedial measures to the railroad embankment based on these investigations should be done under the direction of a professional engineer experienced in the design and construction of tailings dams.

(5) Seepage and Stability Analyses: Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of tailings dams. Included in these analyses, computations should be performed with the reservoir water surface set at the top of the dam. If freeboard will be increased so that the dam will retain the PMF without overtopping, the analyses should be performed with the reservoir water surface set at the maximum pool (PMF) level, and the added embankment height should be considered in the stability analysis.

The necessary data for these analyses would be obtained from additional investigations. The investigations should consist of subsurface exploration and soil sampling and a laboratory testing program to obtain the necessary engineering parameters of the dam and foundation materials. These parameters should be used in an engineering study to evaluate the stability and liquefaction potential of the dam. Concurrent with the exploratory work, groundwater monitoring wells should be installed in the drill holes to obtain water level data that would be used in the stability studies. Remedial measures to the original dam should be based on the results of the stability studies and should be done under the direction of a professional engineer experienced in tailings dam design and construction.

(6) Inspection and Maintenance Program: An inspection and maintenance program should be initiated. Periodic inspections should be made by qualified personnel to observe the performance of the dam. Observations should include indications of instability, such as cracks in the embankment, sloughing, erosion, sudden settlement, or evidence of seepage. Records of these inspections should be maintained, and all maintenance and remedial measures made to the dam should be documented.

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

Item	Page No.
General Information	A-1
Computer Data - Subarea 1 - Watershed above Main Dam	A-2
Computer Data - Subarea 2 - Watershed above Railraod Embankment	A-8
Computer Data - Subarea 3 - Incremental Area Between the Railroad Embankment and the Original Dam	A-15

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

The hydrologic and hydraulic analyses were accomplished by using the computer program "Flood Hydrograph Package, HEC-1, Dam Safety Investigations Version, July 1978". This program was developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The criteria and methodology used are briefly discussed below:

- Probable Maximum Precipitation (PMP) - The 24-hour and 48-hour PMP was obtained from Hydrometeorological Report No. 33. The 6-hour and the 1-hour depth-duration distributions followed Corps of Engineers EM 1110-2-1411 criteria.

- 100-year and/or 10-year storms - The 24-hour storm amounts and distributions were supplied by Corps of Engineers, St. Louis District, Missouri.

- Unit Hydrograph - The Soil Conservation Service (SCS) curvelinear unit hydrograph method was used. Basin lag time was computed by using the SCS Curve Number Method and equation.

- Hydrologic Soil Group, Antecedent Moisture Condition (AMC) and Curve Number (CN) - The hydrologic soil groups for the watershed were obtained from soil survey field sheets of St. Francois County, Missouri prepared by the U.S. Department of Agriculture Soil Conservation Service. For the PMF and floods expressed as a percent of PMF, AMC III conditions were used. For the 100-year and/or 10-year floods, AMC II conditions were assumed. Watershed CN was estimated from field observations and from aerial photos.

- Reservoir Area-Capacity - Areas were measured from the St. Joe State Park, Mo., May 1976, 1 inch = 1000 feet scale, 10-foot contour topographic map. Reservoir elevations and corresponding surface areas were input in the computer program, which determined the reservoir capacities by the Conic Method.

- Reservoir and Spillway Flood Routing - The Modified Puls Method was used for all flood routing through spillway and dam overtopping analyses.

The following pages present the input data listing, the computer program version and its last modification date, together with pertinent computer printouts of results. Definitions of all input and output variable names are presented in the computer program "Users Manual", September 1978, and are not explained herein.

```
A1           ST JOE STATE PARK MAIN DAM    (MISSOURI)       NO. 30277
A2           HEC1 PHASE 1 DAM SAFETY INVESTIGATIONS
A3           RATIOS OF PMF ROUTED THROUGH SPILLWAY AND OVER CREST               SH-05
B      200        0      15       0       0       0       0       0       0       0
B1       5
J        1        7       1
J1     0.4      0.5     0.6     0.7     0.8     0.9     1.0
K        0     INFL                             1       1
K1               FLOOD INFLOW TO MAIN DAM POND
M        1        2    4.33                     1                       1
P        0     26.6     102     120     130     140
T                                                      -1     -80
W2             1.73
X      -10     -0.1     2.5
K        1     LAKE                     1       1       1
K1           FLOOD INFLOW ROUTED THROUGH MAIN DAM POND
Y                               1       1
Y1       1                                         -879.8      -1
Y4   879.8      882     883     884     886   886.5     888     889     890     891
Y4     892      893     894     895     896   896.5
Y5       0      400     700    1054    1384    1550    2360    2960    3620    4390
Y5    5340     6710    8650   11450   16350   20350
$A       0       30      65      95   139.8     197   277.9   374.3
$E     874      878     884     887     890     892     895     900
$$   886.3
$D   895.0
K       99
```

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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
*********************************

RUN  DATE* 79/12/06.
     TIME* 13.13.58.


                    ST JOE STATE PARK MAIN DAM   (MISSOURI)       NO. 30277
                    HECI PHASE I DAM SAFETY INVESTIGATIONS
                    RATIOS OF PMF ROUTED THROUGH SPILLWAY AND OVER CREST           SH-05

                                      JOB SPECIFICATION
          NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
         200       0      15       0       0       0       0       0       0       0
                                JOPER     NWT   LROPT   TRACE
                                    5       0       0       0

                               MULTI-PLAN ANALYSES TO BE PERFORMED
                                  NPLAN= 1 NRTIO= 7 LRTIO= 1
          RTIOS=    .40    .50    .60    .70    .80    .90   1.00


     **********      **********      **********      **********      **********

                                  SUB-AREA RUNOFF COMPUTATION

                  FLOOD INFLOW TO MAIN DAM POND

                      ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                       INFL       0       0       0       0       1       1       0       0

                                        HYDROGRAPH DATA
         IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
             1       2    4.33    0.00    4.33    1.00   0.000       0       1       0

                                          PRECIP DATA
                    SPFE     PMS      R6     R12     R24     R48     R72     R96
                    0.00   26.60  102.00  120.00  130.00  140.00    0.00    0.00

                                           LOSS DATA
     LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
         0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -40.00    0.00    0.00

         CURVE NO = -80.00  WETNESS =  -1.00  EFFECT CN =  80.00

                                    UNIT HYDROGRAPH DATA
                                 TC=  0.00     LAG=  1.73

                                       RECESSION DATA
                         STRTQ=  -11.00    QRCSN=   -.10    RTIOR=  2.50

         UNIT HYDROGRAPH 17 END OF PERIOD ORDINATES, TC=   0.00 HOURS, LAG=   1.73 VOL= 1.00
      [illegible]    143.    357.    619.    877.   1075.   1121.   1116.   [illegible]   [illegible]
      [illegible]    412.    578.    461.    337.    [illegible]   [illegible]   [illegible]   [illegible]   [illegible]
```

83. 66. 54. 43. 35. 28. 22. 18. 14. 12.
10. 8. 6. 5. 3. 2. 0.

0

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.00	0.00	.00	40.	1.02	1.15	101	.04	.03	.01	101.
1.01	.30	2	.00	0.00	.00	36.	1.02	1.30	102	.04	.03	.01	131.
1.01	.45	3	.00	0.00	.00	33.	1.02	1.45	103	.04	.03	.01	163.
1.01	1.00	4	.00	0.00	.00	30.	1.02	2.00	104	.04	.03	.01	195.
1.01	1.15	5	.00	0.00	.00	27.	1.02	2.15	105	.04	.03	.01	225.
1.01	1.30	6	.00	0.00	.00	25.	1.02	2.30	106	.04	.03	.01	252.
1.01	1.45	7	.00	0.00	.00	23.	1.02	2.45	107	.04	.03	.01	276.
1.01	2.00	8	.00	0.00	.00	21.	1.02	3.00	108	.04	.03	.01	295.
1.01	2.15	9	.00	0.00	.00	19.	1.02	3.15	109	.04	.03	.01	310.
1.01	2.30	10	.00	0.00	.00	17.	1.02	3.30	110	.04	.03	.01	322.
1.01	2.45	11	.00	0.00	.00	16.	1.02	3.45	111	.04	.03	.01	333.
1.01	3.00	12	.00	0.00	.00	14.	1.02	4.00	112	.04	.03	.01	342.
1.01	3.15	13	.00	0.00	.00	13.	1.02	4.15	113	.04	.03	.01	350.
1.01	3.30	14	.00	0.00	.00	12.	1.02	4.30	114	.04	.03	.01	356.
1.01	3.45	15	.00	0.00	.00	11.	1.02	4.45	115	.04	.04	.01	362.
1.01	4.00	16	.00	0.00	.00	10.	1.02	5.00	116	.04	.04	.01	367.
1.01	4.15	17	.00	0.00	.00	9.	1.02	5.15	117	.04	.04	.01	371.
1.01	4.30	18	.00	0.00	.00	8.	1.02	5.30	118	.04	.04	.01	375.
1.01	4.45	19	.00	0.00	.00	8.	1.02	5.45	119	.04	.04	.01	378.
1.01	5.00	20	.00	0.00	.00	7.	1.02	6.00	120	.04	.04	.01	381.
1.01	5.15	21	.00	0.00	.00	6.	1.02	6.15	121	.20	.16	.04	391.
1.01	5.30	22	.00	0.00	.00	6.	1.02	6.30	122	.20	.17	.03	417.
1.01	5.45	23	.00	0.00	.00	5.	1.02	6.45	123	.20	.17	.03	466.
1.01	6.00	24	.00	0.00	.00	5.	1.02	7.00	124	.20	.17	.03	547.
1.01	6.15	25	.02	0.00	.02	4.	1.02	7.15	125	.20	.17	.03	663.
1.01	6.30	26	.02	0.00	.02	4.	1.02	7.30	126	.20	.17	.03	802.
1.01	6.45	27	.02	0.00	.02	4.	1.02	7.45	127	.20	.17	.03	953.
1.01	7.00	28	.02	0.00	.02	3.	1.02	8.00	128	.20	.18	.02	1105.
1.01	7.15	29	.02	0.00	.02	3.	1.02	8.15	129	.20	.18	.02	1248.
1.01	7.30	30	.02	0.00	.02	3.	1.02	8.30	130	.20	.18	.02	1378.
1.01	7.45	31	.02	0.00	.02	3.	1.02	8.45	131	.20	.18	.02	1492.
1.01	8.00	32	.02	0.00	.02	2.	1.02	9.00	132	.20	.18	.02	1584.
1.01	8.15	33	.02	0.00	.02	2.	1.02	9.15	133	.20	.18	.02	1659.
1.01	8.30	34	.02	0.00	.02	2.	1.02	9.30	134	.20	.18	.02	1722.
1.01	8.45	35	.02	0.00	.02	2.	1.02	9.45	135	.20	.18	.02	1775.
1.01	9.00	36	.02	0.00	.02	2.	1.02	10.00	136	.20	.18	.02	1821.
1.01	9.15	37	.02	0.00	.02	1.	1.02	10.15	137	.20	.18	.02	1860.
1.01	9.30	38	.02	0.00	.02	1.	1.02	10.30	138	.20	.19	.01	1892.
1.01	9.45	39	.02	0.00	.02	1.	1.02	10.45	139	.20	.19	.01	1921.
1.01	10.00	40	.02	0.00	.02	1.	1.02	11.00	140	.20	.19	.01	1945.
1.01	10.15	41	.02	0.00	.02	1.	1.02	11.15	141	.20	.19	.01	1967.
1.01	10.30	42	.02	0.00	.02	1.	1.02	11.30	142	.20	.19	.01	1985.
1.01	10.45	43	.02	0.00	.02	1.	1.02	11.45	143	.20	.19	.01	2002.
1.01	11.00	44	.02	0.00	.02	1.	1.02	12.00	144	.20	.19	.01	2016.
1.01	11.15	45	.02	0.00	.02	1.	1.02	12.15	145	.68	.64	.04	2057.
1.01	11.30	46	.02	0.00	.02	1.	1.02	12.30	146	.68	.65	.03	2152.
1.01	11.45	47	.02	0.00	.02	1.	1.02	12.45	147	.68	.65	.03	2325.
1.01	12.00	48	.02	0.00	.02	1.	1.02	13.00	148	.68	.65	.03	2615.
1.01	12.15	49	.05	.00	.05	1.	1.02	13.15	149	.91	.77	.03	3034.
1.01	12.30	50	.05	.00	.05	1.	1.02	13.30	150	.91	.77	.02	3551.
1.01	12.45	51	.05	.00	.05	1.	1.02	13.45	151	.91	.77	.02	4123.
1.01	13.00	52	.05	.01	.05	2.	1.02	14.00	152	.91	.79	.02	4710.
1.01	13.15	53	.06	.01	.05	4.	1.02	14.15	153	1.02	1.00	.02	5350.
1.01	13.30	54	.06	.01	.05	7.	1.02	14.30	154	1.02	1.00	.02	5862.

1.01	13.45	55	.06	.01	.05	13.	1.02	14.45	155	1.02	1.00	.02	6568.
1.01	14.00	56	.06	.02	.05	22.	1.02	15.00	156	1.02	1.00	.02	7139.
1.01	14.15	57	.08	.02	.06	34.	1.02	15.15	157	1.03	1.02	.01	7692.
1.01	14.30	58	.08	.02	.05	49.	1.02	15.30	158	2.06	2.04	.03	8286.
1.01	14.45	59	.08	.03	.05	67.	1.02	15.45	159	5.77	5.72	.05	9194.
1.01	15.00	60	.08	.03	.05	88.	1.02	16.00	160	1.44	1.43	.01	10419.
1.01	15.15	61	.08	.03	.05	112.	1.02	16.15	161	.95	.94	.01	11940.
1.01	15.30	62	.16	.07	.09	141.	1.02	16.30	162	.95	.94	.01	13814.
1.01	15.45	63	.44	.24	.21	186.	1.02	16.45	163	.95	.94	.01	15603.
1.01	16.00	64	.11	.07	.04	248.	1.02	17.00	164	.95	.94	.01	16401.
1.01	16.15	65	.07	.05	.03	325.	1.02	17.15	165	.75	.74	.00	17295.
1.01	16.30	66	.07	.05	.03	421.	1.02	17.30	166	.75	.74	.00	17265.
1.01	16.45	67	.07	.05	.03	517.	1.02	17.45	167	.75	.74	.00	16739.
1.01	17.00	68	.07	.05	.03	592.	1.02	18.00	168	.75	.74	.00	15930.
1.01	17.15	69	.06	.04	.02	639.	1.02	18.15	169	.07	.07	.00	14831.
1.01	17.30	70	.06	.04	.02	664.	1.02	18.30	170	.07	.07	.00	13473.
1.01	17.45	71	.06	.04	.02	665.	1.02	18.45	171	.07	.07	.00	12196.
1.01	18.00	72	.06	.04	.02	654.	1.02	19.00	172	.07	.07	.00	10766.
1.01	18.15	73	.01	.00	.00	627.	1.02	19.15	173	.07	.07	.00	9715.
1.01	18.30	74	.01	.00	.00	595.	1.02	19.30	174	.07	.07	.00	8472.
1.01	18.45	75	.01	.00	.00	542.	1.02	19.45	175	.07	.07	.00	7258.
1.01	19.00	76	.01	.00	.00	497.	1.02	20.00	176	.07	.07	.00	6125.
1.01	19.15	77	.01	.00	.00	447.	1.02	20.15	177	.07	.07	.00	5140.
1.01	19.30	78	.01	.00	.00	394.	1.02	20.30	178	.07	.07	.00	4283.
1.01	19.45	79	.01	.00	.00	341.	1.02	20.45	179	.07	.07	.00	3560.
1.01	20.00	80	.01	.00	.00	290.	1.02	21.00	180	.07	.07	.00	2994.
1.01	20.15	81	.01	.00	.00	245.	1.02	21.15	181	.07	.07	.00	2551.
1.01	20.30	82	.01	.00	.00	205.	1.02	21.30	182	.07	.07	.00	2196.
1.01	20.45	83	.01	.00	.00	171.	1.02	21.45	183	.07	.07	.00	1911.
1.01	21.00	84	.01	.00	.00	145.	1.02	22.00	184	.07	.07	.00	1696.
1.01	21.15	85	.01	.00	.00	124.	1.02	22.15	185	.07	.07	.00	1548.
1.01	21.30	86	.01	.00	.00	108.	1.02	22.30	186	.07	.07	.00	1412.
1.01	21.45	87	.01	.00	.00	95.	1.02	22.45	187	.07	.07	.00	1289.
1.01	22.00	88	.01	.00	.00	84.	1.02	23.00	188	.07	.07	.00	1176.
1.01	22.15	89	.01	.00	.00	75.	1.02	23.15	189	.07	.07	.00	1073.
1.01	22.30	90	.01	.00	.00	68.	1.02	23.30	190	.07	.07	.00	987.
1.01	22.45	91	.01	.00	.00	63.	1.02	23.45	191	.07	.07	.00	935.
1.01	23.00	92	.01	.00	.00	58.	1.03	0.00	192	.07	.07	.00	892.
1.01	23.15	93	.01	.00	.00	55.	1.03	.15	193	0.00	0.00	0.00	851.
1.01	23.30	94	.01	.00	.00	52.	1.03	.30	194	0.00	0.00	0.00	808.
1.01	23.45	95	.01	.00	.00	50.	1.03	.45	195	0.00	0.00	0.00	759.
1.02	0.00	96	.01	.00	.00	49.	1.03	1.00	196	0.00	0.00	0.00	704.
1.02	.15	97	.04	.03	.01	48.	1.03	1.15	197	0.00	0.00	0.00	647.
1.02	.30	98	.04	.03	.01	52.	1.03	1.30	198	0.00	0.00	0.00	586.
1.02	.45	99	.04	.03	.01	60.	1.03	1.45	199	0.00	0.00	0.00	534.
1.02	1.00	100	.04	.03	.01	77.	1.03	2.00	200	0.00	0.00	0.00	488.

SUM 37.24 34.40 2.84 183543.
(946.)(874.)(72.)([illegible])

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	17295.	11236.	3669.	1317.	183180.
CMS	490.	317.	110.	[illegible]	10856.
INCHES		24.07	33.25	34.32	34.32
MM		611.47	844.66	871.69	871.63
AC-FT		[illegible]	7574.	7721.	7721.
THOUS CU M		[illegible]	[illegible]	9771.	9771.

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**********          **********          **********          **********          **********

                                   HYDROGRAPH ROUTING

                    FLOOD INFLOW ROUTED THROUGH MAIN DAM POND

                  ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                   LAKE        1        0        0        1        1        1        0        0
                                             ROUTING DATA
          QLOSS    CLOSS      AVG     IRES    ISAME     IOPT     IPMP              LSTR
            0.0    0.000     0.00        1        1        0        0                 0

                  NSTPS    NSTDL      LAG    AMSKK        X      TSK    STORA   ISPRAT
                      1        0        0    0.000    0.000    0.000    -880.       -1


 STAGE      879.30    882.00    883.00    884.00    886.00    886.50    888.00    889.00    890.00    891.00
            892.00    893.00    894.00    895.00    896.00    896.50

  FLOW        0.00    400.00    700.00   1054.00   1384.00   1550.00   2360.00   2960.00   3620.00   4390.00
           5340.00   6710.00   8650.00  11450.00  16350.00  20350.00

SURFACE AREA=     0.       30.       65.       95.      140.      197.      278.      374.

    CAPACITY=     0.       40.      318.      557.      907.     1242.     1951.     3576.

   ELEVATION=   874.      878.      884.      887.      890.      892.      895.      900.

                  CREL    SPWID     COQW     EXPW    ELEVL     COOL    CAREA     EXPL
                 886.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0

                                          DAM DATA
                                 TOPEL     COQD     EXPD   DAMWID
                                 895.0      0.0      0.0       0.
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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .40	RATIO 2 .50	RATIO 3 .60	RATIO 4 .70	RATIO 5 .80	RATIO 6 .90	RATIO 7 1.00
HYDROGRAPH AT	INFL	4.33	1	6918.	8647.	10377.	12106.	13836.	15565.	17295.
		(11.21)		(195.89)(	244.87)(	293.84)(	342.82)(	391.79)(	440.76)(	489.74)(
ROUTED TO	LAKE	4.33	1	4738.	6087.	7610.	9263.	10969.	12991.	14931.
		(11.21)		(134.16)(	172.38)(	215.48)(	262.31)(	310.60)(	367.85)(	422.80)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	879.80	886.30	895.00
STORAGE	102.	493.	1951.
OUTFLOW	0.	1484.	11450.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.40	891.37	0.00	1123.	4738.	0.00	42.75	0.00
.50	892.55	0.00	1353.	6087.	0.00	42.75	0.00
.60	893.46	0.00	1558.	7610.	0.00	42.75	0.00
.70	894.22	0.00	1743.	9263.	0.00	42.50	0.00
.80	894.81	0.00	1904.	10969.	0.00	42.50	0.00
.90	895.31	.31	2039.	12991.	1.50	42.25	0.00
1.00	895.71	.71	2153.	14931.	2.00	42.25	0.00

```
A1      RAILROAD EMBANKMENT ABOVE ORIGIONAL ST JOE STATE PARK   NO. 30277
A2      HEC1 PHASE 1 DAM SAFETY INVESTIGATIONS
A3      RATIOS OF PMF ROUTED THROUGH CULVERT AND OVER CREST                SH-21
B    300       0      10       0       0       0       0       0       0       0
B1     5
J      1       6       1
J1  0.33     0.4     0.5     0.6     0.7     1.0
K      0    INFL                               1       1
K1          FLOOD INFLOW TO RAILROAD EMBANKMENT POND
M      1       2   0.521                       1                       1
P      0    26.6     102     120     130
T                                                     -1     -75
W2          0.63
X    -10    -0.1     2.5
K      1    LAKE                       1       1       1
K1          FLOOD INFLOW ROUTED THROUGH RAILROAD EMBANKMENT POND
Y                              1       1
Y1     1                                               0      -1
Y4 905.2     906     907     908     909     910     911   911.5     912   912.5
Y4   913   913.5     914   914.5     915     916     918
Y5     0       6      22      50      63      85      96     106     133     289
Y5   586    1014    1576    2498    3830    7746   21277
$A     0     8.5    18.0    28.0    40.6    82.4
$E 905.2     906     908     910     912     920
$$   911
$D   914
K     99
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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************

RUN  DATE* 80/01/31.
     TIME* 11.47.12.

          RAILROAD EMBANKMENT ABOVE ORIGIONAL ST JOE STATE PARK   NO. 30277
          HECI PHASE 1 DAM SAFETY INVESTIGATIONS
          RATIOS OF PMF ROUTED THROUGH CULVERT AND OVER CREST              SH-21

                                 JOB SPECIFICATION
       NQ     NHR    NMIN    IDAY    IHR    IMIN   METRC    IPLT    IPRT   NSTAN
      300       0      10       0      0       0       0       0       0       0
                                JOPER    NWT   LROPT   TRACE
                                    5      0       0       0

                           MULTI-PLAN ANALYSES TO BE PERFORMED
                                 NPLAN= 1 NRTIO= 6 LRTIO= 1
           RTIOS=     .33    .40    .50    .60    .70   1.00


  **********        **********        **********        **********        **********

                               SUB-AREA RUNOFF COMPUTATION

          FLOOD INFLOW TO RAILROAD EMBANKMENT POND

                 ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                  INFL       0       0       0       0       1       1       0       0

                                    HYDROGRAPH DATA
       IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
           1       2     .52    0.00     .52    1.00   0.000       0       1       0

                                      PRECIP DATA
              SPFE     PMS      R6     R12     R24     R48     R72     R96
              0.00   26.60  102.00  120.00  130.00    0.00    0.00    0.00

                                       LOSS DATA
   LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
       0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -75.00    0.00    0.00

      CURVE NO =  -75.00  WETNESS =   -1.00  EFFECT CN =   75.00

                                  UNIT HYDROGRAPH DATA
                            TC=  0.30    LAG=   .63

                                     RECESSION DATA
                        STRTQ=  -10.00    QRCSN=   -.10    RTIOR= 2.50

      UNIT HYDROGRAPH 21 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=    .63  VOL= 1.00
     66.      147.      299.      350.      334.      275.      185.      123.       85.       59.
     41.       27.       19.       13.        9.        6.        4.        3.        2.        1.
```

0.

Q MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.03	0.00	.03	5.	1.02	1.10	151	0.00	0.00	0.00	51.
1.01	.20	2	.03	0.00	.03	4.	1.02	1.20	152	0.00	0.00	0.00	46.
1.01	.30	3	.03	0.00	.03	4.	1.02	1.30	153	0.00	0.00	0.00	42.
1.01	.40	4	.03	0.00	.03	4.	1.02	1.40	154	0.00	0.00	0.00	39.
1.01	.50	5	.03	0.00	.03	3.	1.02	1.50	155	0.00	0.00	0.00	35.
1.01	1.00	6	.03	0.00	.03	3.	1.02	2.00	156	0.00	0.00	0.00	32.
1.01	1.10	7	.03	0.00	.03	3.	1.02	2.10	157	0.00	0.00	0.00	29.
1.01	1.20	8	.03	0.00	.03	3.	1.02	2.20	158	0.00	0.00	0.00	27.
1.01	1.30	9	.03	0.00	.03	2.	1.02	2.30	159	0.00	0.00	0.00	24.
1.01	1.40	10	.03	0.00	.03	2.	1.02	2.40	160	0.00	0.00	0.00	22.
1.01	1.50	11	.03	0.00	.03	2.	1.02	2.50	161	0.00	0.00	0.00	20.
1.01	2.00	12	.03	0.00	.03	2.	1.02	3.00	162	0.00	0.00	0.00	19.
1.01	2.10	13	.03	0.00	.03	2.	1.02	3.10	163	0.00	0.00	0.00	17.
1.01	2.20	14	.03	0.00	.03	1.	1.02	3.20	164	0.00	0.00	0.00	15.
1.01	2.30	15	.03	0.00	.03	1.	1.02	3.30	165	0.00	0.00	0.00	14.
1.01	2.40	16	.03	0.00	.03	1.	1.02	3.40	166	0.00	0.00	0.00	13.
1.01	2.50	17	.03	0.00	.03	1.	1.02	3.50	167	0.00	0.00	0.00	12.
1.01	3.00	18	.03	0.00	.03	1.	1.02	4.00	168	0.00	0.00	0.00	11.
1.01	3.10	19	.03	0.00	.03	1.	1.02	4.10	169	0.00	0.00	0.00	10.
1.01	3.20	20	.03	0.00	.03	1.	1.02	4.20	170	0.00	0.00	0.00	9.
1.01	3.30	21	.03	0.00	.03	1.	1.02	4.30	171	0.00	0.00	0.00	8.
1.01	3.40	22	.03	0.00	.03	1.	1.02	4.40	172	0.00	0.00	0.00	7.
1.01	3.50	23	.03	.00	.03	1.	1.02	4.50	173	0.00	0.00	0.00	7.
1.01	4.00	24	.03	.00	.03	1.	1.02	5.00	174	0.00	0.00	0.00	6.
1.01	4.10	25	.03	.00	.03	1.	1.02	5.10	175	0.00	0.00	0.00	6.
1.01	4.20	26	.03	.00	.03	1.	1.02	5.20	176	0.00	0.00	0.00	5.
1.01	4.30	27	.03	.00	.03	1.	1.02	5.30	177	0.00	0.00	0.00	5.
1.01	4.40	28	.03	.00	.03	2.	1.02	5.40	178	0.00	0.00	0.00	4.
1.01	4.50	29	.03	.00	.03	2.	1.02	5.50	179	0.00	0.00	0.00	4.
1.01	5.00	30	.03	.00	.03	3.	1.02	6.00	180	0.00	0.00	0.00	4.
1.01	5.10	31	.03	.00	.03	4.	1.02	6.10	181	0.00	0.00	0.00	3.
1.01	5.20	32	.03	.00	.03	5.	1.02	6.20	182	0.00	0.00	0.00	3.
1.01	5.30	33	.03	.00	.02	6.	1.02	6.30	183	0.00	0.00	0.00	3.
1.01	5.40	34	.03	.00	.02	6.	1.02	6.40	184	0.00	0.00	0.00	2.
1.01	5.50	35	.03	.01	.02	7.	1.02	6.50	185	0.00	0.00	0.00	2.
1.01	6.00	36	.03	.01	.02	8.	1.02	7.00	186	0.00	0.00	0.00	2.
1.01	6.10	37	.13	.03	.10	10.	1.02	7.10	187	0.00	0.00	0.00	2.
1.01	6.20	38	.13	.04	.10	15.	1.02	7.20	188	0.00	0.00	0.00	2.
1.01	6.30	39	.13	.04	.09	24.	1.02	7.30	189	0.00	0.00	0.00	2.
1.01	6.40	40	.13	.05	.08	36.	1.02	7.40	190	0.00	0.00	0.00	1.
1.01	6.50	41	.13	.05	.08	50.	1.02	7.50	191	0.00	0.00	0.00	1.
1.01	7.00	42	.13	.06	.07	64.	1.02	8.00	192	0.00	0.00	0.00	1.
1.01	7.10	43	.13	.06	.07	77.	1.02	8.10	193	0.00	0.00	0.00	1.
1.01	7.20	44	.13	.07	.07	89.	1.02	8.20	194	0.00	0.00	0.00	1.
1.01	7.30	45	.13	.07	.06	100.	1.02	8.30	195	0.00	0.00	0.00	1.
1.01	7.40	46	.13	.07	.06	110.	1.02	8.40	196	0.00	0.00	0.00	1.
1.01	7.50	47	.13	.08	.06	119.	1.02	8.50	197	0.00	0.00	0.00	1.
1.01	8.00	48	.13	.08	.05	128.	1.02	9.00	198	0.00	0.00	0.00	1.
1.01	8.10	49	.13	.08	.05	135.	1.02	9.10	199	0.00	0.00	0.00	1.
1.01	8.20	50	.13	.08	.05	143.	1.02	9.20	200	0.00	0.00	0.00	1.
1.01	8.30	51	.13	.09	.05	149.	1.02	9.30	201	0.00	0.00	0.00	1.
1.01	8.40	52	.13	.09	.04	155.	1.02	9.40	202	0.00	0.00	0.00	0.
1.01	8.50	53	.13	.09	.04	161.	1.02	9.50	203	0.00	0.00	0.00	0.
1.01	9.00	54	.13	.09	.04	166.	1.02	10.00	204	0.00	0.00	0.00	0.
1.01	9.10	55	.13	.09	.04	171.	1.02	10.10	205	0.00	0.00	0.00	0.

1.01	9.20	56	.13	.10	.04	176.	1.02	10.20	206	0.00	0.00	0.00	0.
1.01	9.30	57	.13	.10	.04	180.	1.02	10.30	207	0.00	0.00	0.00	0.
1.01	9.40	58	.13	.10	.03	184.	1.02	10.40	208	0.00	0.00	0.00	0.
1.01	9.50	59	.13	.10	.03	188.	1.02	10.50	209	0.00	0.00	0.00	0.
1.01	10.00	60	.13	.10	.03	191.	1.02	11.00	210	0.00	0.00	0.00	0.
1.01	10.10	61	.13	.10	.03	194.	1.02	11.10	211	0.00	0.00	0.00	0.
1.01	10.20	62	.13	.10	.03	197.	1.02	11.20	212	0.00	0.00	0.00	0.
1.01	10.30	63	.13	.10	.03	200.	1.02	11.30	213	0.00	0.00	0.00	0.
1.01	10.40	64	.13	.11	.03	203.	1.02	11.40	214	0.00	0.00	0.00	0.
1.01	10.50	65	.13	.11	.03	205.	1.02	11.50	215	0.00	0.00	0.00	0.
1.01	11.00	66	.13	.11	.03	208.	1.02	12.00	216	0.00	0.00	0.00	0.
1.01	11.10	67	.13	.11	.02	210.	1.02	12.10	217	0.00	0.00	0.00	0.
1.01	11.20	68	.13	.11	.02	212.	1.02	12.20	218	0.00	0.00	0.00	0.
1.01	11.30	69	.13	.11	.02	214.	1.02	12.30	219	0.00	0.00	0.00	0.
1.01	11.40	70	.13	.11	.02	216.	1.02	12.40	220	0.00	0.00	0.00	0.
1.01	11.50	71	.13	.11	.02	218.	1.02	12.50	221	0.00	0.00	0.00	0.
1.01	12.00	72	.13	.11	.02	219.	1.02	13.00	222	0.00	0.00	0.00	0.
1.01	12.10	73	.45	.39	.07	234.	1.02	13.10	223	0.00	0.00	0.00	0.
1.01	12.20	74	.45	.39	.06	276.	1.02	13.20	224	0.00	0.00	0.00	0.
1.01	12.30	75	.45	.40	.05	357.	1.02	13.30	225	0.00	0.00	0.00	0.
1.01	12.40	76	.45	.40	.05	457.	1.02	13.40	226	0.00	0.00	0.00	0.
1.01	12.50	77	.45	.41	.05	554.	1.02	13.50	227	0.00	0.00	0.00	0.
1.01	13.00	78	.45	.41	.04	636.	1.02	14.00	228	0.00	0.00	0.00	0.
1.01	13.10	79	.54	.50	.05	698.	1.02	14.10	229	0.00	0.00	0.00	0.
1.01	13.20	80	.54	.50	.04	751.	1.02	14.20	230	0.00	0.00	0.00	0.
1.01	13.30	81	.54	.50	.04	806.	1.02	14.30	231	0.00	0.00	0.00	0.
1.01	13.40	82	.54	.51	.03	857.	1.02	14.40	232	0.00	0.00	0.00	0.
1.01	13.50	83	.54	.51	.03	905.	1.02	14.50	233	0.00	0.00	0.00	0.
1.01	14.00	84	.54	.51	.03	942.	1.02	15.00	234	0.00	0.00	0.00	0.
1.01	14.10	85	.68	.64	.03	975.	1.02	15.10	235	0.00	0.00	0.00	0.
1.01	14.20	86	.68	.65	.03	1014.	1.02	15.20	236	0.00	0.00	0.00	0.
1.01	14.30	87	.68	.65	.03	1067.	1.02	15.30	237	0.00	0.00	0.00	0.
1.01	14.40	88	.68	.65	.03	1124.	1.02	15.40	238	0.00	0.00	0.00	0.
1.01	14.50	89	.68	.65	.02	1177.	1.02	15.50	239	0.00	0.00	0.00	0.
1.01	15.00	90	.68	.66	.02	1221.	1.02	16.00	240	0.00	0.00	0.00	0.
1.01	15.10	91	.62	.60	.02	1249.	1.02	16.10	241	0.00	0.00	0.00	0.
1.01	15.20	92	1.03	1.00	.03	1281.	1.02	16.20	242	0.00	0.00	0.00	0.
1.01	15.30	93	1.86	1.81	.05	1376.	1.02	16.30	243	0.00	0.00	0.00	0.
1.01	15.40	94	4.64	4.55	.09	1728.	1.02	16.40	244	0.00	0.00	0.00	0.
1.01	15.50	95	1.34	1.32	.02	2347.	1.02	16.50	245	0.00	0.00	0.00	0.
1.01	16.00	96	.82	.81	.01	3049.	1.02	17.00	246	0.00	0.00	0.00	0.
1.01	16.10	97	.63	.62	.01	3364.	1.02	17.10	247	0.00	0.00	0.00	0.
1.01	16.20	98	.63	.63	.01	3267.	1.02	17.20	248	0.00	0.00	0.00	0.
1.01	16.30	99	.63	.63	.01	2901.	1.02	17.30	249	0.00	0.00	0.00	0.
1.01	16.40	100	.63	.63	.01	2418.	1.02	17.40	250	0.00	0.00	0.00	0.
1.01	16.50	101	.63	.63	.01	2047.	1.02	17.50	251	0.00	0.00	0.00	0.
1.01	17.00	102	.63	.63	.01	1801.	1.02	18.00	252	0.00	0.00	0.00	0.
1.01	17.10	103	.50	.49	.01	1625.	1.02	18.10	253	0.00	0.00	0.00	0.
1.01	17.20	104	.50	.49	.00	1488.	1.02	18.20	254	0.00	0.00	0.00	0.
1.01	17.30	105	.50	.49	.00	1369.	1.02	18.30	255	0.00	0.00	0.00	0.
1.01	17.40	106	.50	.49	.00	1264.	1.02	18.40	256	0.00	0.00	0.00	0.
1.01	17.50	107	.50	.49	.00	1187.	1.02	18.50	257	0.00	0.00	0.00	0.
1.01	18.00	108	.50	.49	.00	1125.	1.02	19.00	258	0.00	0.00	0.00	0.
1.01	18.10	109	.04	.04	.00	1072.	1.02	19.10	259	0.00	0.00	0.00	0.
1.01	18.20	110	.04	.04	.00	964.	1.02	19.20	260	0.00	0.00	0.00	0.
1.01	18.30	111	.04	.04	.00	823.	1.02	19.30	261	0.00	0.00	0.00	0.
1.01	18.40	112	.04	.04	.00	643.	1.02	19.40	262	0.00	0.00	0.00	0.
1.01	18.50	113	.04	.04	.00	483.	1.02	19.50	263	0.00	0.00	0.00	0.
1.01	19.00	114	.04	.04	.00	357.	1.02	20.00	264	0.00	0.00	0.00	0.
1.01	19.10	115	.03	.04	.00	314.	1.02	20.10	265	0.00	0.00	0.00	0.

1.01	19.20	116	.04	.04	.00	286.	1.02	20.20	266	0.00	0.00	0.00	0.
1.01	19.30	117	.04	.04	.00	261.	1.02	20.30	267	0.00	0.00	0.00	0.
1.01	19.40	118	.04	.04	.00	238.	1.02	20.40	268	0.00	0.00	0.00	0.
1.01	19.50	119	.04	.04	.00	217.	1.02	20.50	269	0.00	0.00	0.00	0.
1.01	20.00	120	.04	.04	.00	198.	1.02	21.00	270	0.00	0.00	0.00	0.
1.01	20.10	121	.04	.04	.00	181.	1.02	21.10	271	0.00	0.00	0.00	0.
1.01	20.20	122	.04	.04	.00	165.	1.02	21.20	272	0.00	0.00	0.00	0.
1.01	20.30	123	.04	.04	.00	151.	1.02	21.30	273	0.00	0.00	0.00	0.
1.01	20.40	124	.04	.04	.00	138.	1.02	21.40	274	0.00	0.00	0.00	0.
1.01	20.50	125	.04	.04	.00	126.	1.02	21.50	275	0.00	0.00	0.00	0.
1.01	21.00	126	.04	.04	.00	115.	1.02	22.00	276	0.00	0.00	0.00	0.
1.01	21.10	127	.04	.04	.00	104.	1.02	22.10	277	0.00	0.00	0.00	0.
1.01	21.20	128	.04	.04	.00	95.	1.02	22.20	278	0.00	0.00	0.00	0.
1.01	21.30	129	.04	.04	.00	89.	1.02	22.30	279	0.00	0.00	0.00	0.
1.01	21.40	130	.04	.04	.00	89.	1.02	22.40	280	0.00	0.00	0.00	0.
1.01	21.50	131	.04	.04	.00	89.	1.02	22.50	281	0.00	0.00	0.00	0.
1.01	22.00	132	.04	.04	.00	89.	1.02	23.00	282	0.00	0.00	0.00	0.
1.01	22.10	133	.04	.04	.00	89.	1.02	23.10	283	0.00	0.00	0.00	0.
1.01	22.20	134	.04	.04	.00	89.	1.02	23.20	284	0.00	0.00	0.00	0.
1.01	22.30	135	.04	.04	.00	89.	1.02	23.30	285	0.00	0.00	0.00	0.
1.01	22.40	136	.04	.04	.00	89.	1.02	23.40	286	0.00	0.00	0.00	0.
1.01	22.50	137	.04	.04	.00	89.	1.02	23.50	287	0.00	0.00	0.00	0.
1.01	23.00	138	.04	.04	.00	89.	1.03	0.00	288	0.00	0.00	0.00	0.
1.01	23.10	139	.04	.04	.00	89.	1.03	.10	289	0.00	0.00	0.00	0.
1.01	23.20	140	.04	.04	.00	89.	1.03	.20	290	0.00	0.00	0.00	0.
1.01	23.30	141	.04	.04	.00	89.	1.03	.30	291	0.00	0.00	0.00	0.
1.01	23.40	142	.04	.04	.00	89.	1.03	.40	292	0.00	0.00	0.00	0.
1.01	23.50	143	.04	.04	.00	89.	1.03	.50	293	0.00	0.00	0.00	0.
1.02	0.00	144	.04	.04	.00	89.	1.03	1.00	294	0.00	0.00	0.00	0.
1.02	.10	145	0.00	0.00	0.00	87.	1.03	1.10	295	0.00	0.00	0.00	0.
1.02	.20	146	0.00	0.00	0.00	80.	1.03	1.20	296	0.00	0.00	0.00	0.
1.02	.30	147	0.00	0.00	0.00	73.	1.03	1.30	297	0.00	0.00	0.00	0.
1.02	.40	148	0.00	0.00	0.00	67.	1.03	1.40	298	0.00	0.00	0.00	0.
1.02	.50	149	0.00	0.00	0.00	61.	1.03	1.50	299	0.00	0.00	0.00	0.
1.02	1.00	150	0.00	0.00	0.00	56.	1.03	2.00	300	0.00	0.00	0.00	0.

SUM 34.53 30.88 3.70 63713.
(877.)(784.)(94.)(1806.15)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1166.	1517.	462.	212.	63706.
CMS	33.	43.	13.	6.	1804.
INCHES		25.73	31.54	31.60	31.60
MM		653.56	801.05	802.64	802.64
AC-FT		704.	826.	827.	827.
THOUS CU M		868.	1019.	1020.	1020.

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**********     **********     **********     **********     **********

                          HYDROGRAPH ROUTING

           FLOOD INFLOW ROUTED THROUGH RAILROAD EMBANKMENT POND

           ISTAQ   ICOMP   IECON   ITAPE   JPLT   JPRT   INAME  ISTAGE   IAUTO
            LAKE       1       0       0      1      1      1       0       0
                                  ROUTING DATA
   QLOSS   CLOSS     AVG    IRES   ISAME   IOPT   IPMP          LSTR
     0.0   0.000    0.00       1       1      0      0             0

           NSTPS   NSTDL     LAG   AMSKK       X    TSK   STORA  ISPRAT
               1       0       0   0.000   0.000  0.000     0.      -1

STAGE      905.20    906.00    907.00    908.00    909.00    910.00    911.00    911.50    912.00    912.50
           913.00    913.50    914.00    914.50    915.00    916.00    918.00

FLOW         0.00      6.00     22.00     50.00     68.00     85.00     96.00    106.00    133.00    289.00
           586.00   1014.00   1576.00   2498.00   3830.00   7746.00  21277.00

SURFACE AREA=     0.        9.       18.       28.       41.       82.

    CAPACITY=     0.        2.       28.       74.      142.      624.

   ELEVATION=   905.      906.      908.      910.      912.      920.

             CREL   SPWID    COQW    EXPW   ELEVL    COQL   CAREA    EXPL
            911.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

                                  DAM DATA
                         TOPEL    COQD    EXPD   DAMWID
                         914.0     0.0     0.0       0.
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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .33	RATIO 2 .40	RATIO 3 .50	RATIO 4 .60	RATIO 5 .70	RATIO 6 1.00
				RATIOS APPLIED TO FLOWS					
HYDROGRAPH AT	INFL	.52	1	1110.	1346.	1682.	2018.	2355.	3364.
	(	1.35)	(	31.43)(	38.10)(	47.63)(	57.16)(	66.68)(	95.26)(
ROUTED TO	LAKE	.52	1	404.	640.	1033.	1438.	1841.	2964.
	(	1.35)	(	11.43)(	18.13)(	29.26)(	40.73)(	52.13)(	83.94)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	905.20	911.00	914.00
STORAGE	0.	105.	232.
OUTFLOW	0.	96.	1576.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.33	912.69	0.00	171.	404.	0.00	17.83	0.00
.40	913.06	0.00	188.	640.	0.00	17.17	0.00
.50	913.52	0.00	209.	1033.	0.00	16.83	0.00
.60	913.88	0.00	226.	1438.	0.00	16.67	0.00
.70	914.14	.14	239.	1841.	.67	16.67	0.00
1.00	914.68	.68	267.	2964.	1.67	16.50	0.00

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A1          ST JOE STATE PARK ORIGIONAL DAM  (MISSOURI)        NO. 30277
A2          HEC1 PHASE 1 DAM SAFETY INVESTIGATIONS
A3          PMF (40%) ROUTED THROUGH SPILLWAY AND OVER TOP                              SA-31
B       300       0      10       0       0       0       0       0       0       0
B1        5
J         1       1       1
J1      1.0
K         0   INFL                                1       1
K1               PMF LOCAL INFLOW TO TAILINGS DAM POND
M         1       2   0.112                       1
P         0  11.147     102     120     130
T                                                        -1     -91
W2            0.080
X       -10    -0.1     2.5
K         0   RRDIS                       1       1       1
K1          FLOW FROM BASIN AREA ABOVE RAILROAD EMBANKMENT
M        -1                                       1
N         1       1       1       1       1       1       1       1       1       1
N         1       1       1       1       1       1       1       1       1       1
N         1       1       1       1       1       1       1       1       1       1
N         1       1       1       1       1       1       2       2       2       3
N         4       4       5       5       6       6       7       8       9      10
N        11      13      14      15      16      17      18      19      20      21
N        22      23      25      27      28      30      31      32      34      35
N        36      38      39      40      42      45      49      52      54      57
N        61      64      67      70      73      76      79      82      85      87
N        90      92      94      96      99     104     109     112     114     115
N       116     116     116     116     116     116     116     116     115     115
N       115     115     114     113     113     112     112     112     111     111
N       111     110     110     110     109     109     109     108     108     108
N       108     108     107     106     106     105     105     104     104     104
N       104     104     103     103     102     102     102     101     101     100
N        98      98      98      98      98      97      97      96      96      96
N        96      95      95      95      94      94      93      93      93      92
N        92      91      91      91      90      90      89      89      88      88
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N     87     87     87     86     86     85     85     84     86     83
N     82     81     80     80     79     78     78     77     76     76
N     75     74     74     73     72     71     71     70     69     69
N     68     67     66     66     65     64     64     63     62     61
N     61     60     59     59     58     57     56     56     55     54
N     54     53     52     52     51     50     49     48     47     46
N     45     44     43     42     41     40     39     38     37     37
N     36     35     34     33     32     31     31     30     29     28
N     28     27     26     25     25     24     23     23     22     22
N     21     21     21     20     20     19     19     19     18     18
N     18     17     17     17     17     16     16     16     15     15
N     15     14     14     14     14     13     13     13     12     12
K      2  TOTIN                     1      1      1
K1          TOTAL INFLOW TO TAILINGS DAM POND
K      1  LAKE                      1      1      1

K1        FLOOD ROUTING THROUGH ORIGIONAL TAILINGS DAM POND
Y                              1
Y1     1                                     -893.2      -1
Y4 901.7  902.0  902.25  902.5  902.75  903.0
Y5     0   13.3    54.7  121.5   213.9  333.2
$A     0      8      43    100   150.6
$E   884    887     900    910     920
$$ 901.7
$D 901.7
K     99
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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  26 FEB 79
*********************************

RUN  DATE* 80/01/31.
     TIME* 11.48.07.


                    ST JOE STATE PARK ORIGIONAL DAM  (MISSOURI)        NO. 30277
                    HELL PHASE 1 DAM SAFETY INVESTIGATIONS
                    PMF (40%) ROUTED THROUGH SPILLWAY AND OVER TOP                      SA-31

                                         JOB SPECIFICATION
         NQ      NHR     NMIN     IDAY      IHR     IMIN   METRC     IPLT     IPRT   NSTAN
        300        0       10        0        0        0       0        0        0       0
                                  JOPER      NWT    LROPT   TRACE
                                      5        0        0       0

                          MULTI-PLAN ANALYSES TO BE PERFORMED
                            NPLAN= 1 NRTIO= 1 LRTIO= 1
        RTIOS=    1.00


**********          **********          **********          **********          **********

                                 SUB-AREA RUNOFF COMPUTATION

                     PMF LOCAL INFLOW TO TAILINGS DAM POND

                        ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                         INFL       0       0       0       0       1       1       0       0

                                        HYDROGRAPH DATA
         IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
             1       2     .11    0.00     .11    1.00   0.000       0       0       0

                                          PRECIP DATA
                     SPFE     PMS      R6     R12     R24     R48     R72     R96
                     0.00   11.15  102.00  120.00  139.00    0.00    0.00    0.00

                                           LOSS DATA
      LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
          0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -91.00    0.00    0.00

        CURVE NO = -91.00  WETNESS =   -1.00  EFFECT CN =   91.00

                                     UNIT HYDROGRAPH DATA
                                 TC=  0.00     LAG=   .08

                                       RECESSION DATA
                        STRTQ=  -1[illegible]     QRCSN=    -.10     RTIOR= [illegible].50

       TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

      UNIT HYDROGRAPH  5 END OF PERIOD ORDINATES, TC=    0.[illegible] HOURS, LAG=     .08  VOL= 1.0[illegible]
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322. 90. 18. 4. 0.

0 NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.01	0.00	.01	1.	1.02	1.10	151	0.00	0.00	0.00	4.
1.01	.20	2	.01	0.00	.01	1.	1.02	1.20	152	0.00	0.00	0.00	4.
1.01	.30	3	.01	0.00	.01	1.	1.02	1.30	153	0.00	0.00	0.00	4.
1.01	.40	4	.01	0.00	.01	1.	1.02	1.40	154	0.00	0.00	0.00	3.
1.01	.50	5	.01	0.00	.01	1.	1.02	1.50	155	0.00	0.00	0.00	3.
1.01	1.00	6	.01	0.00	.01	1.	1.02	2.00	156	0.00	0.00	0.00	3.
1.01	1.10	7	.01	0.00	.01	1.	1.02	2.10	157	0.00	0.00	0.00	2.
1.01	1.20	8	.01	0.00	.01	1.	1.02	2.20	158	0.00	0.00	0.00	2.
1.01	1.30	9	.01	0.00	.01	0.	1.02	2.30	159	0.00	0.00	0.00	2.
1.01	1.40	10	.01	0.00	.01	0.	1.02	2.40	160	0.00	0.00	0.00	2.
1.01	1.50	11	.01	0.00	.01	0.	1.02	2.50	161	0.00	0.00	0.00	2.
1.01	2.00	12	.01	0.00	.01	0.	1.02	3.00	162	0.00	0.00	0.00	2.
1.01	2.10	13	.01	0.00	.01	0.	1.02	3.10	163	0.00	0.00	0.00	1.
1.01	2.20	14	.01	0.00	.01	0.	1.02	3.20	164	0.00	0.00	0.00	1.
1.01	2.30	15	.01	0.00	.01	0.	1.02	3.30	165	0.00	0.00	0.00	1.
1.01	2.40	16	.01	.00	.01	0.	1.02	3.40	166	0.00	0.00	0.00	1.
1.01	2.50	17	.01	.00	.01	0.	1.02	3.50	167	0.00	0.00	0.00	1.
1.01	3.00	18	.01	.00	.01	0.	1.02	4.00	168	0.00	0.00	0.00	1.
1.01	3.10	19	.01	.00	.01	0.	1.02	4.10	169	0.00	0.00	0.00	1.
1.01	3.20	20	.01	.00	.01	1.	1.02	4.20	170	0.00	0.00	0.00	1.
1.01	3.30	21	.01	.00	.01	1.	1.02	4.30	171	0.00	0.00	0.00	1.
1.01	3.40	22	.01	.00	.01	1.	1.02	4.40	172	0.00	0.00	0.00	1.
1.01	3.50	23	.01	.00	.01	1.	1.02	4.50	173	0.00	0.00	0.00	1.
1.01	4.00	24	.01	.00	.01	1.	1.02	5.00	174	0.00	0.00	0.00	1.
1.01	4.10	25	.01	.00	.01	1.	1.02	5.10	175	0.00	0.00	0.00	0.
1.01	4.20	26	.01	.00	.01	1.	1.02	5.20	176	0.00	0.00	0.00	0.
1.01	4.30	27	.01	.00	.01	1.	1.02	5.30	177	0.00	0.00	0.00	0.
1.01	4.40	28	.01	.00	.01	1.	1.02	5.40	178	0.00	0.00	0.00	0.
1.01	4.50	29	.01	.00	.01	1.	1.02	5.50	179	0.00	0.00	0.00	0.
1.01	5.00	30	.01	.00	.01	1.	1.02	6.00	180	0.00	0.00	0.00	0.
1.01	5.10	31	.01	.00	.01	2.	1.02	6.10	181	0.00	0.00	0.00	0.
1.01	5.20	32	.01	.00	.01	2.	1.02	6.20	182	0.00	0.00	0.00	0.
1.01	5.30	33	.01	.00	.01	2.	1.02	6.30	183	0.00	0.00	0.00	0.
1.01	5.40	34	.01	.00	.01	2.	1.02	6.40	184	0.00	0.00	0.00	0.
1.01	5.50	35	.01	.00	.01	2.	1.02	6.50	185	0.00	0.00	0.00	0.
1.01	6.00	36	.01	.00	.01	2.	1.02	7.00	186	0.00	0.00	0.00	0.
1.01	6.10	37	.06	.02	.03	7.	1.02	7.10	187	0.00	0.00	0.00	0.
1.01	6.20	38	.06	.02	.03	10.	1.02	7.20	188	0.00	0.00	0.00	0.
1.01	6.30	39	.06	.03	.03	11.	1.02	7.30	189	0.00	0.00	0.00	0.
1.01	6.40	40	.06	.03	.03	12.	1.02	7.40	190	0.00	0.00	0.00	0.
1.01	6.50	41	.06	.03	.02	13.	1.02	7.50	191	0.00	0.00	0.00	0.
1.01	7.00	42	.06	.03	.02	14.	1.02	8.00	192	0.00	0.00	0.00	0.
1.01	7.10	43	.06	.03	.02	15.	1.02	8.10	193	0.00	0.00	0.00	0.
1.01	7.20	44	.06	.04	.02	15.	1.02	8.20	194	0.00	0.00	0.00	0.
1.01	7.30	45	.06	.04	.02	16.	1.02	8.30	195	0.00	0.00	0.00	0.
1.01	7.40	46	.06	.04	.02	16.	1.02	8.40	196	0.00	0.00	0.00	0.
1.01	7.50	47	.06	.04	.02	17.	1.02	8.50	197	0.00	0.00	0.00	0.
1.01	8.00	48	.06	.04	.02	17.	1.02	9.00	198	0.00	0.00	0.00	0.
1.01	8.10	49	.06	.04	.01	18.	1.02	9.10	199	0.00	0.00	0.00	0.
1.01	8.20	50	.06	.04	.01	18.	1.02	9.20	200	0.00	0.00	0.00	0.
1.01	8.30	51	.06	.04	.01	19.	1.02	9.30	201	0.00	0.00	0.00	0.
1.01	8.40	52	.06	.04	.01	19.	1.02	9.40	202	0.00	0.00	0.00	0.
1.01	8.50	53	.06	.04	.01	19.	1.02	9.50	203	0.00	0.00	0.00	0.
1.01	9.00	54	.06	.04	.01	19.	1.02	10.00	204	0.00	0.00	0.00	0.
1.01	9.10	55	.06	.05	.01	19.	1.02	10.10	205	0.00	0.00	0.00	0.

1.01	9.20	56	.06	.05	.01	20.	1.02	10.20	206	0.00	0.00	0.00	0.
1.01	9.30	57	.06	.05	.01	20.	1.02	10.30	207	0.00	0.00	0.00	0.
1.01	9.40	58	.06	.05	.01	20.	1.02	10.40	208	0.00	0.00	0.00	0.
1.01	9.50	59	.06	.05	.01	20.	1.02	10.50	209	0.00	0.00	0.00	0.
1.01	10.00	60	.06	.05	.01	20.	1.02	11.00	210	0.00	0.00	0.00	0.
1.01	10.10	61	.06	.05	.01	21.	1.02	11.10	211	0.00	0.00	0.00	0.
1.01	10.20	62	.06	.05	.01	21.	1.02	11.20	212	0.00	0.00	0.00	0.
1.01	10.30	63	.06	.05	.01	21.	1.02	11.30	213	0.00	0.00	0.00	0.
1.01	10.40	64	.06	.05	.01	21.	1.02	11.40	214	0.00	0.00	0.00	0.
1.01	10.50	65	.06	.05	.01	21.	1.02	11.50	215	0.00	0.00	0.00	0.
1.01	11.00	66	.06	.05	.01	21.	1.02	12.00	216	0.00	0.00	0.00	0.
1.01	11.10	67	.06	.05	.01	21.	1.02	12.10	217	0.00	0.00	0.00	0.
1.01	11.20	68	.06	.05	.01	21.	1.02	12.20	218	0.00	0.00	0.00	0.
1.01	11.30	69	.06	.05	.01	22.	1.02	12.30	219	0.00	0.00	0.00	0.
1.01	11.40	70	.06	.05	.01	22.	1.02	12.40	220	0.00	0.00	0.00	0.
1.01	11.50	71	.06	.05	.01	22.	1.02	12.50	221	0.00	0.00	0.00	0.
1.01	12.00	72	.06	.05	.01	22.	1.02	13.00	222	0.00	0.00	0.00	0.
1.01	12.10	73	.19	.17	.02	61.	1.02	13.10	223	0.00	0.00	0.00	0.
1.01	12.20	74	.19	.17	.01	73.	1.02	13.20	224	0.00	0.00	0.00	0.
1.01	12.30	75	.19	.18	.01	76.	1.02	13.30	225	0.00	0.00	0.00	0.
1.01	12.40	76	.19	.18	.01	77.	1.02	13.40	226	0.00	0.00	0.00	0.
1.01	12.50	77	.19	.18	.01	77.	1.02	13.50	227	0.00	0.00	0.00	0.
1.01	13.00	78	.19	.18	.01	78.	1.02	14.00	228	0.00	0.00	0.00	0.
1.01	13.10	79	.23	.22	.01	90.	1.02	14.10	229	0.00	0.00	0.00	0.
1.01	13.20	80	.23	.22	.01	93.	1.02	14.20	230	0.00	0.00	0.00	0.
1.01	13.30	81	.23	.22	.01	94.	1.02	14.30	231	0.00	0.00	0.00	0.
1.01	13.40	82	.23	.22	.01	95.	1.02	14.40	232	0.00	0.00	0.00	0.
1.01	13.50	83	.23	.22	.01	95.	1.02	14.50	233	0.00	0.00	0.00	0.
1.01	14.00	84	.23	.22	.01	95.	1.02	15.00	234	0.00	0.00	0.00	0.
1.01	14.10	85	.28	.28	.01	113.	1.02	15.10	235	0.00	0.00	0.00	0.
1.01	14.20	86	.28	.28	.01	119.	1.02	15.20	236	0.00	0.00	0.00	0.
1.01	14.30	87	.28	.28	.01	120.	1.02	15.30	237	0.00	0.00	0.00	0.
1.01	14.40	88	.28	.28	.01	120.	1.02	15.40	238	0.00	0.00	0.00	0.
1.01	14.50	89	.28	.28	.01	121.	1.02	15.50	239	0.00	0.00	0.00	0.
1.01	15.00	90	.28	.28	.01	121.	1.02	16.00	240	0.00	0.00	0.00	0.
1.01	15.10	91	.26	.25	.00	113.	1.02	16.10	241	0.00	0.00	0.00	0.
1.01	15.20	92	.43	.43	.01	166.	1.02	16.20	242	0.00	0.00	0.00	0.
1.01	15.30	93	.78	.77	.01	291.	1.02	16.30	243	0.00	0.00	0.00	0.
1.01	15.40	94	1.94	1.92	.02	697.	1.02	16.40	244	0.00	0.00	0.00	0.
1.01	15.50	95	.56	.56	.00	368.	1.02	16.50	245	0.00	0.00	0.00	0.
1.01	16.00	96	.35	.34	.00	198.	1.02	17.00	246	0.00	0.00	0.00	0.
1.01	16.10	97	.27	.26	.00	132.	1.02	17.10	247	0.00	0.00	0.00	0.
1.01	16.20	98	.27	.26	.00	117.	1.02	17.20	248	0.00	0.00	0.00	0.
1.01	16.30	99	.27	.26	.00	115.	1.02	17.30	249	0.00	0.00	0.00	0.
1.01	16.40	100	.27	.26	.00	114.	1.02	17.40	250	0.00	0.00	0.00	0.
1.01	16.50	101	.27	.26	.00	114.	1.02	17.50	251	0.00	0.00	0.00	0.
1.01	17.00	102	.27	.26	.00	114.	1.02	18.00	252	0.00	0.00	0.00	0.
1.01	17.10	103	.21	.21	.00	96.	1.02	18.10	253	0.00	0.00	0.00	0.
1.01	17.20	104	.21	.21	.00	91.	1.02	18.20	254	0.00	0.00	0.00	0.
1.01	17.30	105	.21	.21	.00	90.	1.02	18.30	255	0.00	0.00	0.00	0.
1.01	17.40	106	.21	.21	.00	90.	1.02	18.40	256	0.00	0.00	0.00	0.
1.01	17.50	107	.21	.21	.00	90.	1.02	18.50	257	0.00	0.00	0.00	0.
1.01	18.00	108	.21	.21	.00	90.	1.02	19.00	258	0.00	0.00	0.00	0.
1.01	18.10	109	.02	.02	.00	66.	1.02	19.10	259	0.00	0.00	0.00	0.
1.01	18.20	110	.02	.02	.00	60.	1.02	19.20	260	0.00	0.00	0.00	0.
1.01	18.30	111	.02	.02	.00	55.	1.02	19.30	261	0.00	0.00	0.00	0.
1.01	18.40	112	.02	.02	.00	53.	1.02	19.40	262	0.00	0.00	0.00	0.
1.01	18.50	113	.02	.02	.00	46.	1.02	19.50	263	0.00	0.00	0.00	0.
1.01	19.00	114	.02	.02	.00	42.	1.02	20.00	264	0.00	0.00	0.00	0.
1.01	19.10	115	.02	.02	.00	39.	1.02	20.10	265	0.00	0.00	0.00	0.

1.01	19.20	116	.02	.02	.00	35.	1.02	20.20	266	0.00	0.00	0.00	0.
1.01	19.30	117	.02	.02	.00	32.	1.02	20.30	267	0.00	0.00	0.00	0.
1.01	19.40	118	.02	.02	.00	29.	1.02	20.40	268	0.00	0.00	0.00	0.
1.01	19.50	119	.02	.02	.00	26.	1.02	20.50	269	0.00	0.00	0.00	0.
1.01	20.00	120	.02	.02	.00	24.	1.02	21.00	270	0.00	0.00	0.00	0.
1.01	20.10	121	.02	.02	.00	22.	1.02	21.10	271	0.00	0.00	0.00	0.
1.01	20.20	122	.02	.02	.00	20.	1.02	21.20	272	0.00	0.00	0.00	0.
1.01	20.30	123	.02	.02	.00	18.	1.02	21.30	273	0.00	0.00	0.00	0.
1.01	20.40	124	.02	.02	.00	17.	1.02	21.40	274	0.00	0.00	0.00	0.
1.01	20.50	125	.02	.02	.00	15.	1.02	21.50	275	0.00	0.00	0.00	0.
1.01	21.00	126	.02	.02	.00	14.	1.02	22.00	276	0.00	0.00	0.00	0.
1.01	21.10	127	.02	.02	.00	13.	1.02	22.10	277	0.00	0.00	0.00	0.
1.01	21.20	128	.02	.02	.00	12.	1.02	22.20	278	0.00	0.00	0.00	0.
1.01	21.30	129	.02	.02	.00	11.	1.02	22.30	279	0.00	0.00	0.00	0.
1.01	21.40	130	.02	.02	.00	10.	1.02	22.40	280	0.00	0.00	0.00	0.
1.01	21.50	131	.02	.02	.00	9.	1.02	22.50	281	0.00	0.00	0.00	0.
1.01	22.00	132	.02	.02	.00	8.	1.02	23.00	282	0.00	0.00	0.00	0.
1.01	22.10	133	.02	.02	.00	8.	1.02	23.10	283	0.00	0.00	0.00	0.
1.01	22.20	134	.02	.02	.00	8.	1.02	23.20	284	0.00	0.00	0.00	0.
1.01	22.30	135	.02	.02	.00	8.	1.02	23.30	285	0.00	0.00	0.00	0.
1.01	22.40	136	.02	.02	.00	8.	1.02	23.40	286	0.00	0.00	0.00	0.
1.01	22.50	137	.02	.02	.00	8.	1.02	23.50	287	0.00	0.00	0.00	0.
1.01	23.00	138	.02	.02	.00	8.	1.03	0.00	288	0.00	0.00	0.00	0.
1.01	23.10	139	.02	.02	.00	8.	1.03	.10	289	0.00	0.00	0.00	0.
1.01	23.20	140	.02	.02	.00	8.	1.03	.20	290	0.00	0.00	0.00	0.
1.01	23.30	141	.02	.02	.00	8.	1.03	.30	291	0.00	0.00	0.00	0.
1.01	23.40	142	.02	.02	.00	8.	1.03	.40	292	0.00	0.00	0.00	0.
1.01	23.50	143	.02	.02	.00	8.	1.03	.50	293	0.00	0.00	0.00	0.
1.02	0.00	144	.02	.02	.00	8.	1.03	1.00	294	0.00	0.00	0.00	0.
1.02	.10	145	0.00	0.00	0.00	7.	1.03	1.10	295	0.00	0.00	0.00	0.
1.02	.20	146	0.00	0.00	0.00	7.	1.03	1.20	296	0.00	0.00	0.00	0.
1.02	.30	147	0.00	0.00	0.00	6.	1.03	1.30	297	0.00	0.00	0.00	0.
1.02	.40	148	0.00	0.00	0.00	6.	1.03	1.40	298	0.00	0.00	0.00	0.
1.02	.50	149	0.00	0.00	0.00	5.	1.03	1.50	299	0.00	0.00	0.00	0.
1.02	1.00	150	0.00	0.00	0.00	5.	1.03	2.00	300	0.00	0.00	0.00	0.

SUM 14.49 13.37 1.12 6333.
(368.)(340.)(28.)(179.33)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	637.	134.	55.	21.	6335.
CMS	29.	4.	1.	1.	179.
INCHES		11.0?	14.56	14.62	14.62
MM		281.71	369.81	371.35	371.35
AC-FT		[illegible]	87.	87.	87.
THOUS CU M		82.	107.	108.	108.

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

FLOW FROM BASIN AREA ABOVE RAILROAD EMBANKMENT

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
RRDIS	0	0	0	1	1	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	0.00	0.00	0.00	1.00	0.000	0	0	0

INPUT HYDROGRAPH

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	2.	2.	2.	3.
4.	4.	5.	5.	6.	6.	7.	8.	9.	10.
11.	13.	14.	15.	16.	17.	18.	19.	20.	21.
22.	23.	25.	27.	28.	30.	31.	32.	34.	35.
36.	38.	39.	40.	42.	45.	49.	52.	54.	57.
61.	64.	67.	70.	73.	76.	79.	82.	85.	87.
90.	92.	94.	96.	99.	104.	109.	112.	114.	115.
116.	116.	116.	116.	116.	116.	116.	116.	115.	115.
115.	115.	114.	113.	113.	112.	112.	112.	111.	111.
111.	110.	110.	110.	109.	109.	109.	108.	108.	108.
108.	108.	107.	106.	106.	105.	105.	104.	104.	104.
104.	104.	103.	103.	102.	102.	102.	101.	101.	100.
98.	98.	98.	98.	98.	97.	97.	96.	96.	96.
96.	95.	95.	95.	94.	94.	93.	93.	93.	92.
92.	91.	91.	91.	90.	90.	89.	89.	88.	88.
87.	87.	87.	86.	86.	85.	85.	84.	84.	83.
82.	81.	80.	80.	79.	78.	78.	77.	76.	76.
75.	74.	74.	73.	72.	71.	71.	70.	69.	69.
68.	67.	66.	66.	65.	64.	64.	63.	62.	61.
61.	60.	59.	59.	58.	57.	56.	56.	55.	54.
54.	53.	52.	52.	51.	50.	49.	48.	47.	46.
45.	44.	43.	42.	41.	40.	39.	38.	37.	37.
36.	35.	34.	33.	32.	31.	31.	30.	29.	28.
28.	27.	26.	25.	25.	24.	23.	23.	22.	22.
21.	21.	21.	20.	20.	19.	19.	19.	18.	18.
18.	17.	17.	17.	17.	16.	16.	16.	15.	15.
15.	14.	14.	14.	14.	13.	13.	13.	12.	12.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	116.	112.	92.	55.	16591.
CMS	3.	3.	3.	2.	470.
INCHES		.00	.00	.00	.00
MM		.00	.00	.00	.00
AC-FT		56.	183.	223.	223.
THOUS CU M		69.	226.	275.	275.

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**********          **********          **********          **********          **********

                                   HYDROGRAPH ROUTING

                    FLOOD ROUTING THROUGH ORIGIONAL TAILINGS DAM POND
                         ISTAQ    ICOMP    IECON    ITAPE    JPLT     JPRT     INAME    ISTAGE    IAUTO
                         LAKE        1        0        0        1        1        1        0         0
                                                ROUTING DATA
                 QLOSS    CLOSS      AVG     IRES    ISAME     IOPT     IPMP              LSTR
                   0.0    0.000     0.00        1        0        0        0                 0

                         NSTPS    NSTDL      LAG    AMSKK        X      TSK    STORA    ISPRAT
                             1        0        0    0.000    0.000    0.000    -893.       -1

STAGE          901.70      902.00      902.25      902.50      902.75      903.00

FLOW             0.00       13.30       54.70      121.50      213.90      333.20

SURFACE AREA=       0.          8.         48.        100.        151.

CAPACITY=           0.          8.        336.       1060.       2304.

ELEVATION=        884.        887.        900.        910.        920.

                         CREL    SPWID     COQW     EXPW    ELEVL     COQL    CAREA     EXPL
                        901.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0

                                                   DAM DATA
                                          TOPEL     COQD     EXPD    DAMWID
                                          901.7      0.0      0.0        0.
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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00
HYDROGRAPH AT	INFL	.11	1	697.
	(	.29)	(	19.75)(
HYDROGRAPH AT	RROI>	0.00	1	116.
	(	0.00)	(	3.28)(
2 COMBINED	TOTIN	.11	1	793.
	(	.29)	(	22.47)(
ROUTED TO	LAKE	.11	1	0.
	(	.29)	(	0.00)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	893.20	901.70	901.70
STORAGE	100.	423.	423.
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	901.55	0.00	415.	0.	0.00	0.00	0.00

```
A1      ST JOE STATE PARK ORIGIONAL DAM  (MISSOURI)       NO. 30277
A2      HEC1 PHASE 1 DAM SAFETY INVESTIGATIONS
A3      PMF (50%)  ROUTED THROUGH SPILLWAY AND OVER DAM TOP                SH-32
B    300       0      10       0       0       0       0       0       0       0
B1     5
J      1       1       1
J1   1.0
K      0    INFL                               1       1
K1             PMF LOCAL  INFLOW TO TAILINGS DAM POND
M      1       2   0.112                       1
P      0  13.726     102     120     130
T                                                     -1     -91
W2         0.080
X    -10    -0.1     2.5
K      0   RRDIS                       1       1       1
K1      FLOW FROM BASIN AREA ABOVE RAILROAD EMBANKMENT
M     -1                                       1
N      1       1       1       1       1       1       1       1       1       1
N      1       1       1       1       1       1       1       1       1       1
N      1       1       1       1       1       1       1       1       1       1
N      1       1       1       1       2       2       2       2       3       3
N      4       5       5       6       6       8       9      10      11      12
N     14      15      16      18      19      20      21      23      25      27
N     29      31      32      34      36      38      39      41      42      44
N     45      47      48      50      51      53      56      59      62      66
N     69      73      76      80      83      86      88      90      93      95
N     98     102     104     107     109     112     115     118     119     120
N    120     120     120     119     119     118     118     117     117     117
N    116     116     115     115     114     113     112     112     112     111
N    111     110     110     110     109     109     109     108     108     108
N    108     108     108     107     107     107     106     106     105     105
N    105     104     104     104     104     104     104     103     103     103
N    103     102     102     101     100      99      99      98      97      97
N     97      96      96      96      96      95      95      94      94      94
N     93      93      92      92      92      91      91      90      90      89
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N      89      89      88      88      87      87      86      86      85      85
N      84      84      83      82      81      81      80      79      79      78
N      77      77      76      75      74      74      73      72      72      71
N      70      70      69      68      67      67      66      65      65      64
N      63      62      62      61      60      60      59      58      57      57
N      56      55      55      54      53      52      52      51      50      50
N      49      46      47      45      44      43      43      42      41      40
N      39      38      37      36      35      34      33      33      32      31
N      30      29      29      28      27      26      26      25      24      23
N      23      22      22      21      21      21      20      20      20      19
N      19      19      18      18      18      17      17      17      16      16
N      16      15      15      15      14      14      14      14      13      13
K       2    TOTIN                      1       1       1
K1             TOTAL  INFLOW  TO  TAILINGS  DAM  POND
K       1     LAKE                      1       1       1

K1          FLOOD  ROUTING  THROUGH  ORIGIONAL  TAILINGS  DAM  POND
Y                                    1
Y1      1                                                -893.2       -1
Y4  901.7   902.0  902.25   902.5  902.75   903.0
Y5      0    13.3    54.7   121.5   213.9   333.2
$A      0       8      48     100   150.6
$E    884     887     900     910     920
$$  901.7
$D  901.7
K      99
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********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
********************************

RUN  DATE* 80/01/31.
     TIME* 12.15.24.

                    ST JOE STATE PARK URIGIONAL DAM  (MISSOURI)        NO. 30277
                    HEC1 PHASE 1 DAM SAFETY INVESTIGATIONS
                    PMF (50%)  ROUTED THROUGH SPILLWAY AND OVER DAM TOP              SH-32

                                        JOB SPECIFICATION
            NQ       NHR      NMIN     IDAY      IHR      IMIN     METRC     IPLT     IPRT    NSTAN
           300         0        10        0        0         0        0        0        0        0
                                        JOPER      NWT     LROPT    TRACE
                                           5         0        0        0

                                  MULTI-PLAN ANALYSES TO BE PERFORMED
                                       NPLAN= 1 NRTIO= 1 LRTIO= 1
         RTIOS=    1.00


     **********        **********        **********        **********        **********

                                        SUB-AREA RUNOFF COMPUTATION

                    PMF LOCAL INFLOW TO TAILINGS DAM POND

                         ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE   IAUTO
                         INFL         0        0        0        0        1        1        0        0

                                          HYDROGRAPH DATA
           IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
               1        2      .11     0.00      .11     1.00    0.000        0        0        0

                                            PRECIP DATA
                   SPFE      PMS       R6      R12      R24      R48      R72      R96
                   0.00    13.73   102.00   120.00   130.00     0.00     0.00     0.00

                                             LOSS DATA
      LROPT    STRKR    DLTKR    RTIOL    ERAIN    STRKS    RTIOK    STRTL    CNSTL    ALSMX    RTIMP
          0     0.00     0.00     1.00     0.00     0.00     1.00    -1.00   -91.00     0.00     0.00

          CURVE NO =  -91.00   WETNESS =   -1.00   EFFECT CN =    91.00

                                        UNIT HYDROGRAPH DATA
                                   TC=  0.00      LAG=    .08

                                           RECESSION DATA
                            STRTQ=   -10.00     QRCSN=     -.10     RTIOR= 2.50

          TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

         UNIT HYDROGRAPH  5 END OF PERIOD ORDINATES, TC=     0.00 HOURS, LAG=    .08   VOL= 1.00
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322. 90. 18. 4. 0.

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.02	0.00	.02	1.	1.02	1.10	151	0.00	0.00	0.00	5.
1.01	.20	2	.02	0.00	.02	1.	1.02	1.20	152	0.00	0.00	0.00	5.
1.01	.30	3	.02	0.00	.02	1.	1.02	1.30	153	0.00	0.00	0.00	4.
1.01	.40	4	.02	0.00	.02	1.	1.02	1.40	154	0.00	0.00	0.00	4.
1.01	.50	5	.02	0.00	.02	1.	1.02	1.50	155	0.00	0.00	0.00	4.
1.01	1.00	6	.02	0.00	.02	1.	1.02	2.00	156	0.00	0.00	0.00	3.
1.01	1.10	7	.02	0.00	.02	1.	1.02	2.10	157	0.00	0.00	0.00	3.
1.01	1.20	8	.02	0.00	.02	1.	1.02	2.20	158	0.00	0.00	0.00	3.
1.01	1.30	9	.02	0.00	.02	0.	1.02	2.30	159	0.00	0.00	0.00	3.
1.01	1.40	10	.02	0.00	.02	0.	1.02	2.40	160	0.00	0.00	0.00	2.
1.01	1.50	11	.02	0.00	.02	0.	1.02	2.50	161	0.00	0.00	0.00	2.
1.01	2.00	12	.02	0.00	.02	0.	1.02	3.00	162	0.00	0.00	0.00	2.
1.01	2.10	13	.02	.00	.02	0.	1.02	3.10	163	0.00	0.00	0.00	2.
1.01	2.20	14	.02	.00	.02	0.	1.02	3.20	164	0.00	0.00	0.00	2.
1.01	2.30	15	.02	.00	.01	1.	1.02	3.30	165	0.00	0.00	0.00	1.
1.01	2.40	16	.02	.00	.01	1.	1.02	3.40	166	0.00	0.00	0.00	1.
1.01	2.50	17	.02	.00	.01	1.	1.02	3.50	167	0.00	0.00	0.00	1.
1.01	3.00	18	.02	.00	.01	1.	1.02	4.00	168	0.00	0.00	0.00	1.
1.01	3.10	19	.02	.00	.01	1.	1.02	4.10	169	0.00	0.00	0.00	1.
1.01	3.20	20	.02	.00	.01	1.	1.02	4.20	170	0.00	0.00	0.00	1.
1.01	3.30	21	.02	.00	.01	1.	1.02	4.30	171	0.00	0.00	0.00	1.
1.01	3.40	22	.02	.00	.01	2.	1.02	4.40	172	0.00	0.00	0.00	1.
1.01	3.50	23	.02	.00	.01	2.	1.02	4.50	173	0.00	0.00	0.00	1.
1.01	4.00	24	.02	.00	.01	2.	1.02	5.00	174	0.00	0.00	0.00	1.
1.01	4.10	25	.02	.00	.01	2.	1.02	5.10	175	0.00	0.00	0.00	1.
1.01	4.20	26	.02	.00	.01	2.	1.02	5.20	176	0.00	0.00	0.00	1.
1.01	4.30	27	.02	.00	.01	2.	1.02	5.30	177	0.00	0.00	0.00	0.
1.01	4.40	28	.02	.01	.01	2.	1.02	5.40	178	0.00	0.00	0.00	0.
1.01	4.50	29	.02	.01	.01	2.	1.02	5.50	179	0.00	0.00	0.00	0.
1.01	5.00	30	.02	.01	.01	2.	1.02	6.00	180	0.00	0.00	0.00	0.
1.01	5.10	31	.02	.01	.01	3.	1.02	6.10	181	0.00	0.00	0.00	0.
1.01	5.20	32	.02	.01	.01	3.	1.02	6.20	182	0.00	0.00	0.00	0.
1.01	5.30	33	.02	.01	.01	3.	1.02	6.30	183	0.00	0.00	0.00	0.
1.01	5.40	34	.02	.01	.01	3.	1.02	6.40	184	0.00	0.00	0.00	0.
1.01	5.50	35	.02	.01	.01	3.	1.02	6.50	185	0.00	0.00	0.00	0.
1.01	6.00	36	.02	.01	.01	3.	1.02	7.00	186	0.00	0.00	0.00	0.
1.01	6.10	37	.07	.03	.04	11.	1.02	7.10	187	0.00	0.00	0.00	0.
1.01	6.20	38	.07	.04	.03	15.	1.02	7.20	188	0.00	0.00	0.00	0.
1.01	6.30	39	.07	.04	.03	17.	1.02	7.30	189	0.00	0.00	0.00	0.
1.01	6.40	40	.07	.04	.03	18.	1.02	7.40	190	0.00	0.00	0.00	0.
1.01	6.50	41	.07	.04	.02	19.	1.02	7.50	191	0.00	0.00	0.00	0.
1.01	7.00	42	.07	.05	.02	20.	1.02	8.00	192	0.00	0.00	0.00	0.
1.01	7.10	43	.07	.05	.02	20.	1.02	8.10	193	0.00	0.00	0.00	0.
1.01	7.20	44	.07	.05	.02	21.	1.02	8.20	194	0.00	0.00	0.00	0.
1.01	7.30	45	.07	.05	.02	22.	1.02	8.30	195	0.00	0.00	0.00	0.
1.01	7.40	46	.07	.05	.02	22.	1.02	8.40	196	0.00	0.00	0.00	0.
1.01	7.50	47	.07	.05	.02	23.	1.02	8.50	197	0.00	0.00	0.00	0.
1.01	8.00	48	.07	.05	.01	23.	1.02	9.00	198	0.00	0.00	0.00	0.
1.01	8.10	49	.07	.05	.01	24.	1.02	9.10	199	0.00	0.00	0.00	0.
1.01	8.20	50	.07	.06	.01	24.	1.02	9.20	200	0.00	0.00	0.00	0.
1.01	8.30	51	.07	.06	.01	24.	1.02	9.30	201	0.00	0.00	0.00	0.
1.01	8.40	52	.07	.06	.01	25.	1.02	9.40	202	0.00	0.00	0.00	0.
1.01	8.50	53	.07	.06	.01	25.	1.02	9.50	203	0.00	0.00	0.00	0.
1.01	9.00	54	.07	.06	.01	25.	1.02	10.00	204	0.00	0.00	0.00	0.
1.01	9.10	55	.07	.06	.01	25.	1.02	10.10	205	0.00	0.00	0.00	0.

[illegible]	[illegible]	56	.07	.06	.01	26.	1.02	10.20	206	0.00	0.00	0.00	0.
[illegible]	[illegible]	57	.07	.06	.01	26.	1.02	10.30	207	0.00	0.00	0.00	0.
[illegible]	[illegible]	58	.07	.06	.01	26.	1.02	10.40	208	0.00	0.00	0.00	0.
[illegible]	[illegible]	59	.07	.06	.01	26.	1.02	10.50	209	0.00	0.00	0.00	0.
[illegible]	[illegible]	60	.07	.06	.01	26.	1.02	11.00	210	0.00	0.00	0.00	0.
[illegible]	10.10	61	.07	.06	.01	27.	1.02	11.10	211	0.00	0.00	0.00	0.
[illegible]	[illegible]	62	.07	.06	.01	27.	1.02	11.20	212	0.00	0.00	0.00	0.
[illegible]	10.30	63	.07	.06	.01	27.	1.02	11.30	213	0.00	0.00	0.00	0.
1.01	10.40	64	.07	.06	.01	27.	1.02	11.40	214	0.00	0.00	0.00	0.
1.01	10.50	65	.07	.06	.01	27.	1.02	11.50	215	0.00	0.00	0.00	0.
1.01	11.00	66	.07	.06	.01	27.	1.02	12.00	216	0.00	0.00	0.00	0.
1.01	11.10	67	.07	.06	.01	27.	1.02	12.10	217	0.00	0.00	0.00	0.
1.01	11.20	68	.07	.06	.01	27.	1.02	12.20	218	0.00	0.00	0.00	0.
1.01	11.30	69	.07	.06	.01	27.	1.02	12.30	219	0.00	0.00	0.00	0.
1.01	11.40	70	.07	.06	.01	28.	1.02	12.40	220	0.00	0.00	0.00	0.
1.01	11.50	71	.07	.06	.00	28.	1.02	12.50	221	0.00	0.00	0.00	0.
1.01	12.00	72	.07	.06	.00	28.	1.02	13.00	222	0.00	0.00	0.00	0.
1.01	12.10	73	.23	.22	.01	77.	1.02	13.10	223	0.00	0.00	0.00	0.
1.01	12.20	74	.23	.22	.01	92.	1.02	13.20	224	0.00	0.00	0.00	0.
1.01	12.30	75	.23	.22	.01	95.	1.02	13.30	225	0.00	0.00	0.00	0.
1.01	12.40	76	.23	.22	.01	96.	1.02	13.40	226	0.00	0.00	0.00	0.
1.01	12.50	77	.23	.22	.01	97.	1.02	13.50	227	0.00	0.00	0.00	0.
1.01	13.00	78	.23	.22	.01	97.	1.02	14.00	228	0.00	0.00	0.00	0.
1.01	13.10	79	.28	.27	.01	112.	1.02	14.10	229	0.00	0.00	0.00	0.
1.01	13.20	80	.28	.27	.01	117.	1.02	14.20	230	0.00	0.00	0.00	0.
1.01	13.30	81	.28	.27	.01	118.	1.02	14.30	231	0.00	0.00	0.00	0.
1.01	13.40	82	.28	.27	.01	118.	1.02	14.40	232	0.00	0.00	0.00	0.
1.01	13.50	83	.28	.27	.01	118.	1.02	14.50	233	0.00	0.00	0.00	0.
1.01	14.00	84	.28	.27	.01	119.	1.02	15.00	234	0.00	0.00	0.00	0.
1.01	14.10	85	.35	.34	.01	141.	1.02	15.10	235	0.00	0.00	0.00	0.
1.01	14.20	86	.35	.34	.01	147.	1.02	15.20	236	0.00	0.00	0.00	0.
1.01	14.30	87	.35	.34	.01	149.	1.02	15.30	237	0.00	0.00	0.00	0.
1.01	14.40	88	.35	.34	.01	149.	1.02	15.40	238	0.00	0.00	0.00	0.
1.01	14.50	89	.35	.35	.00	150.	1.02	15.50	239	0.00	0.00	0.00	0.
1.01	15.00	90	.35	.35	.00	150.	1.02	16.00	240	0.00	0.00	0.00	0.
1.01	15.10	91	.32	.32	.00	140.	1.02	16.10	241	0.00	0.00	0.00	0.
1.01	15.20	92	.53	.53	.01	205.	1.02	16.20	242	0.00	0.00	0.00	0.
1.01	15.30	93	.96	.95	.01	360.	1.02	16.30	243	0.00	0.00	0.00	0.
1.01	15.40	94	2.39	2.38	.02	862.	1.02	16.40	244	0.00	0.00	0.00	0.
1.01	15.50	95	.69	.69	.00	455.	1.02	16.50	245	0.00	0.00	0.00	0.
1.01	16.00	96	.43	.42	.00	244.	1.02	17.00	246	0.00	0.00	0.00	0.
1.01	16.10	97	.33	.33	.00	163.	1.02	17.10	247	0.00	0.00	0.00	0.
1.01	16.20	98	.33	.33	.00	144.	1.02	17.20	248	0.00	0.00	0.00	0.
1.01	16.30	99	.33	.33	.00	141.	1.02	17.30	249	0.00	0.00	0.00	0.
1.01	16.40	100	.33	.33	.00	141.	1.02	17.40	250	0.00	0.00	0.00	0.
1.01	16.50	101	.33	.33	.00	141.	1.02	17.50	251	0.00	0.00	0.00	0.
1.01	17.00	102	.33	.33	.00	141.	1.02	18.00	252	0.00	0.00	0.00	0.
1.01	17.10	103	.26	.26	.00	117.	1.02	18.10	253	0.00	0.00	0.00	0.
1.01	17.20	104	.26	.26	.00	112.	1.02	18.20	254	0.00	0.00	0.00	0.
1.01	17.30	105	.26	.26	.00	111.	1.02	18.30	255	0.00	0.00	0.00	0.
1.01	17.40	106	.26	.26	.00	111.	1.02	18.40	256	0.00	0.00	0.00	0.
1.01	17.50	107	.26	.26	.00	111.	1.02	18.50	257	0.00	0.00	0.00	0.
1.01	18.00	108	.26	.26	.00	111.	1.02	19.00	258	0.00	0.00	0.00	0.
1.01	18.10	109	.02	.02	.00	83.	1.02	19.10	259	0.00	0.00	0.00	0.
1.01	18.20	110	.02	.02	.00	76.	1.02	19.20	260	0.00	0.00	0.00	0.
1.01	18.30	111	.02	.02	.00	68.	1.02	19.30	261	0.00	0.00	0.00	0.
1.01	18.40	112	.02	.02	.00	62.	1.02	19.40	262	0.00	0.00	0.00	0.
1.01	18.50	113	.02	.02	.01	55.	1.02	19.50	263	0.00	0.00	0.00	0.
1.01	19.00	114	.02	.02	[illegible]	51.	1.02	20.00	264	0.00	0.00	0.00	0.
1.01	19.10	115	[illegible]	.02	[illegible]	47.	1.02	20.10	265	0.00	0.00	0.00	0.

1.01	19.20	116	.02	.02	.00	43.	1.02	20.20	266	0.00	0.00	0.00	0.
1.01	19.30	117	.02	.02	.00	39.	1.02	20.30	267	0.00	0.00	0.00	0.
1.01	19.40	118	.02	.02	.00	36.	1.02	20.40	268	0.00	0.00	0.00	0.
1.01	19.50	119	.02	.02	.00	32.	1.02	20.50	269	0.00	0.00	0.00	0.
1.01	20.00	120	.02	.02	.00	30.	1.02	21.00	270	0.00	0.00	0.00	0.
1.01	20.10	121	.02	.02	.00	27.	1.02	21.10	271	0.00	0.00	0.00	0.
1.01	20.20	122	.02	.02	.00	25.	1.02	21.20	272	0.00	0.00	0.00	0.
1.01	20.30	123	.02	.02	.00	22.	1.02	21.30	273	0.00	0.00	0.00	0.
1.01	20.40	124	.02	.02	.00	21.	1.02	21.40	274	0.00	0.00	0.00	0.
1.01	20.50	125	.02	.02	.00	19.	1.02	21.50	275	0.00	0.00	0.00	0.
1.01	21.00	126	.02	.02	.00	17.	1.02	22.00	276	0.00	0.00	0.00	0.
1.01	21.10	127	.02	.02	.00	16.	1.02	22.10	277	0.00	0.00	0.00	0.
1.01	21.20	128	.02	.02	.00	14.	1.02	22.20	278	0.00	0.00	0.00	0.
1.01	21.30	129	.02	.02	.00	13.	1.02	22.30	279	0.00	0.00	0.00	0.
1.01	21.40	130	.02	.02	.00	12.	1.02	22.40	280	0.00	0.00	0.00	0.
1.01	21.50	131	.02	.02	.00	11.	1.02	22.50	281	0.00	0.00	0.00	0.
1.01	22.00	132	.02	.02	.00	10.	1.02	23.00	282	0.00	0.00	0.00	0.
1.01	22.10	133	.02	.02	.00	10.	1.02	23.10	283	0.00	0.00	0.00	0.
1.01	22.20	134	.02	.02	.00	10.	1.02	23.20	284	0.00	0.00	0.00	0.
1.01	22.30	135	.02	.02	.00	10.	1.02	23.30	285	0.00	0.00	0.00	0.
1.01	22.40	136	.02	.02	.00	10.	1.02	23.40	286	0.00	0.00	0.00	0.
1.01	22.50	137	.02	.02	.00	10.	1.02	23.50	287	0.00	0.00	0.00	0.
1.01	23.00	138	.02	.02	.00	10.	1.03	0.00	288	0.00	0.00	0.00	0.
1.01	23.10	139	.02	.02	.00	10.	1.03	.10	289	0.00	0.00	0.00	0.
1.01	23.20	140	.02	.02	.00	10.	1.03	.20	290	0.00	0.00	0.06	0.
1.01	23.30	141	.02	.02	.00	10.	1.03	.30	291	0.00	0.00	0.00	0.
1.01	23.40	142	.02	.02	.00	10.	1.03	.40	292	0.00	0.00	0.00	0.
1.01	23.50	143	.02	.02	.00	10.	1.03	.50	293	0.00	0.00	0.00	0.
1.02	0.00	144	.02	.02	.00	10.	1.03	1.00	294	0.00	0.00	0.00	0.
1.02	.10	145	0.00	0.00	0.00	9.	1.03	1.10	295	0.00	0.00	0.00	0.
1.02	.20	146	0.00	0.00	0.00	8.	1.03	1.20	296	0.00	0.00	0.00	0.
1.02	.30	147	0.00	0.00	0.00	8.	1.03	1.30	297	0.00	0.00	0.00	0.
1.02	.40	148	0.00	0.00	0.00	7.	1.03	1.40	298	0.00	0.00	0.00	0.
1.02	.50	149	0.00	0.00	0.00	6.	1.03	1.50	299	0.00	0.00	0.00	0.
1.02	1.00	150	0.00	0.00	0.00	6.	1.03	2.00	300	0.00	0.00	0.00	0.

SUM 17.85 16.71 1.13 7911.
(453.)(424.)(29.)(224.01)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	862.	265.	55.	26.	7908.
CMS	24.	5.	2.	1.	224.
INCHES		13.74	18.18	18.25	18.25
MM		349.06	461.68	463.43	463.43
AC-FT		82.	109.	109.	109.
THOUS CU M		101.	134.	134.	134.

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SUB-AREA RUNOFF COMPUTATION

FLOW FROM BASIN AREA ABOVE RAILROAD EMBANKMENT

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
PROIS	0	0	0	1	1	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	0.00	0.00	0.00	1.00	0.000	0	0	0

INPUT HYDROGRAPH

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	2.	2.	2.	2.	3.	3.
4.	5.	5.	6.	6.	8.	9.	10.	11.	12.
14.	15.	16.	18.	19.	20.	21.	23.	25.	27.
29.	31.	32.	34.	36.	38.	39.	41.	42.	44.
45.	47.	48.	50.	51.	53.	56.	59.	62.	66.
69.	73.	76.	80.	83.	86.	88.	90.	93.	95.
98.	102.	104.	107.	109.	112.	115.	118.	119.	120.
120.	120.	120.	119.	119.	118.	118.	117.	117.	117.
116.	116.	115.	115.	114.	113.	112.	112.	112.	111.
111.	110.	110.	110.	109.	109.	109.	108.	108.	108.
108.	108.	108.	107.	107.	107.	106.	106.	105.	105.
105.	104.	104.	104.	104.	104.	104.	103.	103.	103.
103.	102.	102.	101.	100.	99.	99.	98.	97.	97.
97.	96.	96.	96.	96.	95.	95.	94.	94.	94.
93.	93.	92.	92.	92.	91.	91.	90.	90.	89.
89.	88.	88.	88.	87.	87.	86.	85.	85.	85.
84.	84.	83.	82.	81.	81.	80.	79.	79.	78.
77.	77.	76.	75.	74.	74.	73.	72.	72.	71.
70.	70.	69.	68.	67.	67.	66.	65.	65.	64.
63.	62.	62.	61.	60.	60.	59.	58.	57.	57.
56.	55.	55.	54.	53.	52.	52.	51.	50.	50.
49.	48.	47.	45.	44.	43.	43.	42.	41.	40.
39.	38.	37.	36.	35.	34.	33.	33.	32.	31.
30.	29.	29.	28.	27.	26.	26.	25.	24.	23.
23.	22.	22.	21.	21.	21.	20.	20.	20.	19.
19.	19.	18.	18.	18.	17.	17.	17.	16.	16.
16.	15.	15.	15.	15.	14.	14.	14.	13.	13.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	120.	114.	75.	58.	17351.
CMS	3.	3.	2.	2.	491.
INCHES		.00	.00	.00	.00
MM		.00	.00	.00	.00
AC-FT		57.	148.	233.	239.
THOUS CU M		70.	183.	287.	295.

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**********          **********          **********          **********          **********

                                    HYDROGRAPH ROUTING

                    FLOOD ROUTING THROUGH ORIGIONAL TAILINGS DAM POND

                    ISTAQ     ICOMP     IECON     ITAPE      JPLT      JPRT     INAME    ISTAGE     IAUTO
                    LAKE          1         0         0         1         1         1         0         0
                                                ROUTING DATA
          QLOSS     CLOSS       AVG      IRES     ISAME      IOPT      IPMP                LSTR
            0.0     0.000      0.00         1         0         0         0                   0

                    NSTPS     NSTDL       LAG     AMSKK         X       TSK     STORA    ISPRAT
                        1         0         0     0.000     0.000     0.000     -893.       -1

   STAGE      901.70     902.00     902.25     902.50     902.75     903.00

    FLOW        0.00      13.10      54.70     121.50     213.90     333.20

SURFACE AREA=       0.        8.        48.       100.       151.

    CAPACITY=       0.        9.       336.      1060.      2304.

   ELEVATION=     884.      897.       900.       910.       920.

                    CREL     SPWID      COQW      EXPW     ELEVL      COQL     CAREA      EXPL
                   901.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0

                                                 DAM DATA
                                       TOPEL      COQD      EXPD    DAMWID
                                       901.7       0.0       0.0        0.
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00
HYDROGRAPH AT	INFL	.11	1	862.
	(	.29)	(	24.40)(
HYDROGRAPH AT	RRDIS	0.00	1	120.
	(	0.00)	(	3.40)(
2 COMBINED	TOTIN	.11	1	969.
	(	.29)	(	27.43)(
ROUTED TO	LAKE	.11	1	12.
	(	.29)	(	.35)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	893.20	901.70	901.70
STORAGE	100.	423.	423.
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	901.98	.28	439.	12.	10.50	50.00	0.00

```
A1        ST JOE STATE PARK ORIGIONAL DAM  (MISSOURI)        NO. 30277
A2        HEC1 PHASE 1 DAM SAFETY INVESTIGATIONS
A3        PMF (80%)  ROUTED THROUGH SPILLWAY AND OVER DAM TOP                 SH-33
B     300       0      10       0       0       0       0       0       0       0
B1      5
J       1       1       1
J1    1.0
K       0    INFL                               1       1
K1               PMF LOCAL  INFLOW TO TAILINGS DAM POND
M       1       2   0.112                       1
P       0  21.638     102     120     130
T                                                      -1     -91
W2          0.080
X     -10    -0.1     2.5
K       0    RRDIS                      1       1       1
K1        FLOW FROM BASIN AREA ABOVE RAILROAD EMBANKMENT
M      -1                                       1
N       1       2       2       2       2       2       2       2       2       2
N       2       2       2       2       2       2       2       2       2       2
N       2       2       2       1       1       1       1       1       1       1
N       1       2       2       2       2       3       3       3       4       4
N       5       6       6       8       9      11      13      15      16      18
N      20      22      25      28      31      33      36      39      42      44
N      46      49      51      52      54      55      57      58      59      61
N      62      63      65      66      68      71      74      78      82      86
N      88      91      94      97     101     104     108     110     111     113
N     114     115     117     118     120     122     160     248     282     260
N     215     169     132     123     123     122     121     121     120     120
N     119     119     118     117     116     115     114     114     113     112
N     112     112     111     111     110     110     110     110     109     109
N     109     108     108     108     108     108     108     108     108     108
N     107     107     107     107     106     106     106     106     105     105
N     104     104     103     103     103     102     102     102     102     102
N     101     101     100      99      98      98      97      97      97      96
N      96      96      96      95      95      94      94      93      93      93
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N     92     92     91     91     90     90     90     89     89     88
N     88     87     87     87     86     86     85     85     84     83
N     83     82     81     80     80     79     78     78     77     76
N     76     75     74     73     73     72     71     71     70     70
N     69     68     67     66     66     65     64     63     63     62
N     61     61     60     59     58     58     57     56     56     55
N     54     54     53     52     51     51     50     49     48     47
N     46     45     44     43     42     41     40     39     38     37
N     36     36     35     34     33     32     31     31     30     29
N     28     27     27     26     25     25     24     23     22     22
N     22     21     21     20     20     20     19     19     19     18
N     18     18     17     17     17     16     16     16     16     15
K      2   TOTIN                 1      1      1
K1           TOTAL INFLOW TO TAILINGS DAM POND
K      1    LAKE                 1      1      1

K1        FLOOD ROUTING THROUGH ORIGIONAL TAILINGS DAM POND
Y                              1
Y1     1                                     -893.2      -1
Y4 901.7  902.0 902.25  902.5 902.75  903.0
Y5     0   13.3   54.7  121.5  213.9  333.2
$A     0      8     48    100  150.6
$E   884    887    900    910    920
$$ 901.7
$D 901.7
K     99
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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
*********************************

RUN  DATE* 80/01/31.
     TIME* 12.20.47.

                 ST JOE STATE PARK ORIGIONAL DAM  (MISSOURI)       NO. 30277
                 HECI PHASE I DAM SAFETY INVESTIGATIONS
                 PMF (80%)  ROUTED THROUGH SPILLWAY AND OVER DAM TOP              SH-33

                                      JOB SPECIFICATION
         NO      NHR     NMIN     IDAY      IHR      IMIN    METRC     IPLT     IPRT    NSTAN
        300        0       10        0        0         0        0        0        0        0
                                 JOPER      NWT     LROPT    TRACE
                                     5        0         0        0

                               MULTI-PLAN ANALYSES TO BE PERFORMED
                                  NPLAN= 1 NRTIO= 1 LRTIO= 1
       RTIOS=   1.00

   **********         **********         **********         **********         **********

                                 SUB-AREA RUNOFF COMPUTATION

                      PMF LOCAL INFLOW TO TAILINGS DAM POND

                         ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                          INFL        0        0        0        0        1        1        0        0

                                        HYDROGRAPH DATA
         IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
             1        2      .11     0.00      .11     1.00    0.000        0        0        0

                                          PRECIP DATA
                    SPFE      PMS       R6      R12      R24      R48      R72      R96
                    0.00    21.64   102.00   120.00   130.00     0.00     0.00     0.00

                                           LOSS DATA
   LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
       0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -91.00    0.00    0.00

      CURVE NO =  -91.00  WETNESS =   -1.00  EFFECT CN =   91.00

                                      UNIT HYDROGRAPH DATA
                                  TC=  0.00     LAG=   .08

                                         RECESSION DATA
                         STRTQ=  -10.00     QRCSN=    -.10     RTIOR= 2.50

      TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

     UNIT HYDROGRAPH  5 END-OF-PERIOD ORDINATES, TC=    0.00 HOURS, LAG=     .08  VOL= 1.00
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122. 90. 18. 4. 0.

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.02	0.00	.02	1.	1.02	1.10	151	0.00	0.00	0.00	8.
1.01	.20	2	.02	0.00	.02	1.	1.02	1.20	152	0.00	0.00	0.00	8.
1.01	.30	3	.02	0.00	.02	1.	1.02	1.30	153	0.00	0.00	0.00	7.
1.01	.40	4	.02	0.00	.02	1.	1.02	1.40	154	0.00	0.00	0.00	6.
1.01	.50	5	.02	0.00	.02	1.	1.02	1.50	155	0.00	0.00	0.00	6.
1.01	1.00	6	.02	0.00	.02	1.	1.02	2.00	156	0.00	0.00	0.00	5.
1.01	1.10	7	.02	0.00	.02	1.	1.02	2.10	157	0.00	0.00	0.00	5.
1.01	1.20	8	.02	0.00	.02	1.	1.02	2.20	158	0.00	0.00	0.00	4.
1.01	1.30	9	.02	.00	.02	1.	1.02	2.30	159	0.00	0.00	0.00	4.
1.01	1.40	10	.02	.00	.02	1.	1.02	2.40	160	0.00	0.00	0.00	4.
1.01	1.50	11	.02	.00	.02	1.	1.02	2.50	161	0.00	0.00	0.00	3.
1.01	2.00	12	.02	.00	.02	2.	1.02	3.00	162	0.00	0.00	0.00	3.
1.01	2.10	13	.02	.00	.02	2.	1.02	3.10	163	0.00	0.00	0.00	3.
1.01	2.20	14	.02	.01	.02	2.	1.02	3.20	164	0.00	0.00	0.00	2.
1.01	2.30	15	.02	.01	.02	3.	1.02	3.30	165	0.00	0.00	0.00	2.
1.01	2.40	16	.02	.01	.02	3.	1.02	3.40	166	0.00	0.00	0.00	2.
1.01	2.50	17	.02	.01	.02	3.	1.02	3.50	167	0.00	0.00	0.00	2.
1.01	3.00	18	.02	.01	.02	4.	1.02	4.00	168	0.00	0.00	0.00	2.
1.01	3.10	19	.02	.01	.02	4.	1.02	4.10	169	0.00	0.00	0.00	2.
1.01	3.20	20	.02	.01	.01	4.	1.02	4.20	170	0.00	0.00	0.00	1.
1.01	3.30	21	.02	.01	.01	4.	1.02	4.30	171	0.00	0.00	0.00	1.
1.01	3.40	22	.02	.01	.01	5.	1.02	4.40	172	0.00	0.00	0.00	1.
1.01	3.50	23	.02	.01	.01	5.	1.02	4.50	173	0.00	0.00	0.00	1.
1.01	4.00	24	.02	.01	.01	5.	1.02	5.00	174	0.00	0.00	0.00	1.
1.01	4.10	25	.02	.01	.01	5.	1.02	5.10	175	0.00	0.00	0.00	1.
1.01	4.20	26	.02	.01	.01	5.	1.02	5.20	176	0.00	0.00	0.00	1.
1.01	4.30	27	.02	.01	.01	5.	1.02	5.30	177	0.00	0.00	0.00	1.
1.01	4.40	28	.02	.01	.01	6.	1.02	5.40	178	0.00	0.00	0.00	1.
1.01	4.50	29	.02	.01	.01	6.	1.02	5.50	179	0.00	0.00	0.00	1.
1.01	5.00	30	.02	.01	.01	6.	1.02	6.00	180	0.00	0.00	0.00	1.
1.01	5.10	31	.02	.01	.01	6.	1.02	6.10	181	0.00	0.00	0.00	1.
1.01	5.20	32	.02	.01	.01	6.	1.02	6.20	182	0.00	0.00	0.00	0.
1.01	5.30	33	.02	.01	.01	6.	1.02	6.30	183	0.00	0.00	0.00	0.
1.01	5.40	34	.02	.01	.01	6.	1.02	6.40	184	0.00	0.00	0.00	0.
1.01	5.50	35	.02	.02	.01	7.	1.02	6.50	185	0.00	0.00	0.00	0.
1.01	6.00	36	.02	.02	.01	7.	1.02	7.00	186	0.00	0.00	0.00	0.
1.01	6.10	37	.11	.07	.04	25.	1.02	7.10	187	0.00	0.00	0.00	0.
1.01	6.20	38	.11	.08	.03	31.	1.02	7.20	188	0.00	0.00	0.00	0.
1.01	6.30	39	.11	.08	.03	34.	1.02	7.30	189	0.00	0.00	0.00	0.
1.01	6.40	40	.11	.08	.03	35.	1.02	7.40	190	0.00	0.00	0.00	0.
1.01	6.50	41	.11	.09	.02	37.	1.02	7.50	191	0.00	0.00	0.00	0.
1.01	7.00	42	.11	.09	.02	38.	1.02	8.00	192	0.00	0.00	0.00	0.
1.01	7.10	43	.11	.09	.02	38.	1.02	8.10	193	0.00	0.00	0.00	0.
1.01	7.20	44	.11	.09	.02	39.	1.02	8.20	194	0.00	0.00	0.00	0.
1.01	7.30	45	.11	.09	.02	40.	1.02	8.30	195	0.00	0.00	0.00	0.
1.01	7.40	46	.11	.09	.01	40.	1.02	8.40	196	0.00	0.00	0.00	0.
1.01	7.50	47	.11	.09	.01	41.	1.02	8.50	197	0.00	0.00	0.00	0.
1.01	8.00	48	.11	.10	.01	41.	1.02	9.00	198	0.00	0.00	0.00	0.
1.01	8.10	49	.11	.10	.01	42.	1.02	9.10	199	0.00	0.00	0.00	0.
1.01	8.20	50	.11	.10	.01	42.	1.02	9.20	200	0.00	0.00	0.00	0.
1.01	8.30	51	.11	.10	.01	42.	1.02	9.30	201	0.00	0.00	0.00	0.
1.01	8.40	52	.11	.10	.01	43.	1.02	9.40	202	0.00	0.00	0.00	0.
1.01	8.50	53	.11	.10	.01	43.	1.02	9.50	203	0.00	0.00	0.00	0.
1.01	9.00	54	.11	.10	.01	43.	1.02	10.00	204	0.00	0.00	0.00	0.
1.01	9.10	55	.11	.10	.01	43.	1.02	10.10	205	0.00	0.00	0.00	0.

1.01	9.20	56	.11	.10	.01	44.	1.02	10.20	206	0.00	0.00	0.00	0.
1.01	9.30	57	.11	.10	.01	44.	1.02	10.30	207	0.00	0.00	0.00	0.
1.01	9.40	58	.11	.10	.01	44.	1.02	10.40	208	0.00	0.00	0.00	0.
1.01	9.50	59	.11	.10	.01	44.	1.02	10.50	209	0.00	0.00	0.00	0.
1.01	10.00	60	.11	.10	.01	44.	1.02	11.00	210	0.00	0.00	0.00	0.
1.01	10.10	61	.11	.10	.01	44.	1.02	11.10	211	0.00	0.00	0.00	0.
1.01	10.20	62	.11	.10	.01	45.	1.02	11.20	212	0.00	0.00	0.00	0.
1.01	10.30	63	.11	.10	.01	45.	1.02	11.30	213	0.00	0.00	0.00	0.
1.01	10.40	64	.11	.10	.00	45.	1.02	11.40	214	0.00	0.00	0.00	0.
1.01	10.50	65	.11	.10	.00	45.	1.02	11.50	215	0.00	0.00	0.00	0.
1.01	11.00	66	.11	.10	.00	45.	1.02	12.00	216	0.00	0.00	0.00	0.
1.01	11.10	67	.11	.10	.00	45.	1.02	12.10	217	0.00	0.00	0.00	0.
1.01	11.20	68	.11	.10	.00	45.	1.02	12.20	218	0.00	0.00	0.00	0.
1.01	11.30	69	.11	.10	.00	45.	1.02	12.30	219	0.00	0.00	0.00	0.
1.01	11.40	70	.11	.10	.00	45.	1.02	12.40	220	0.00	0.00	0.00	0.
1.01	11.50	71	.11	.10	.00	45.	1.02	12.50	221	0.00	0.00	0.00	0.
1.01	12.00	72	.11	.10	.00	45.	1.02	13.00	222	0.00	0.00	0.00	0.
1.01	12.10	73	.37	.36	.01	127.	1.02	13.10	223	0.00	0.00	0.00	0.
1.01	12.20	74	.37	.36	.01	150.	1.02	13.20	224	0.00	0.00	0.00	0.
1.01	12.30	75	.37	.36	.01	155.	1.02	13.30	225	0.00	0.00	0.00	0.
1.01	12.40	76	.37	.36	.01	156.	1.02	13.40	226	0.00	0.00	0.00	0.
1.01	12.50	77	.37	.36	.01	156.	1.02	13.50	227	0.00	0.00	0.00	0.
1.01	13.00	78	.37	.36	.01	157.	1.02	14.00	228	0.00	0.00	0.00	0.
1.01	13.10	79	.44	.43	.01	180.	1.02	14.10	229	0.00	0.00	0.00	0.
1.01	13.20	80	.44	.44	.01	187.	1.02	14.20	230	0.00	0.00	0.00	0.
1.01	13.30	81	.44	.44	.01	189.	1.02	14.30	231	0.00	0.00	0.00	0.
1.01	13.40	82	.44	.44	.00	189.	1.02	14.40	232	0.00	0.00	0.00	0.
1.01	13.50	83	.44	.44	.00	189.	1.02	14.50	233	0.00	0.00	0.00	0.
1.01	14.00	84	.44	.44	.00	189.	1.02	15.00	234	0.00	0.00	0.00	0.
1.01	14.10	85	.55	.55	.00	225.	1.02	15.10	235	0.00	0.00	0.00	0.
1.01	14.20	86	.55	.55	.00	235.	1.02	15.20	236	0.00	0.00	0.00	0.
1.01	14.30	87	.55	.55	.00	237.	1.02	15.30	237	0.00	0.00	0.00	0.
1.01	14.40	88	.55	.55	.00	238.	1.02	15.40	238	0.00	0.00	0.00	0.
1.01	14.50	89	.55	.55	.00	238.	1.02	15.50	239	0.00	0.00	0.00	0.
1.01	15.00	90	.55	.55	.00	238.	1.02	16.00	240	0.00	0.00	0.00	0.
1.01	15.10	91	.50	.50	.00	222.	1.02	16.10	241	0.00	0.00	0.00	0.
1.01	15.20	92	.84	.83	.00	326.	1.02	16.20	242	0.00	0.00	0.00	0.
1.01	15.30	93	1.51	1.50	.01	570.	1.02	16.30	243	0.00	0.00	0.00	0.
1.01	15.40	94	1.77	1.76	.01	1364.	1.02	16.40	244	0.00	0.00	0.00	0.
1.01	15.50	95	1.09	1.09	.00	719.	1.02	16.50	245	0.00	0.00	0.00	0.
1.01	16.00	96	.67	.67	.00	386.	1.02	17.00	246	0.00	0.00	0.00	0.
1.01	16.10	97	.51	.51	.00	258.	1.02	17.10	247	0.00	0.00	0.00	0.
1.01	16.20	98	.51	.51	.00	228.	1.02	17.20	248	0.00	0.00	0.00	0.
1.01	16.30	99	.51	.51	.00	223.	1.02	17.30	249	0.00	0.00	0.00	0.
1.01	16.40	100	.51	.51	.00	223.	1.02	17.40	250	0.00	0.00	0.00	0.
1.01	16.50	101	.51	.51	.00	223.	1.02	17.50	251	0.00	0.00	0.00	0.
1.01	17.00	102	.51	.51	.00	223.	1.02	18.00	252	0.00	0.00	0.00	0.
1.01	17.10	103	.40	.40	.00	187.	1.02	18.10	253	0.00	0.00	0.00	0.
1.01	17.20	104	.40	.40	.00	177.	1.02	18.20	254	0.00	0.00	0.00	0.
1.01	17.30	105	.40	.40	.00	176.	1.02	18.30	255	0.00	0.00	0.00	0.
1.01	17.40	106	.40	.40	.00	175.	1.02	18.40	256	0.00	0.00	0.00	0.
1.01	17.50	107	.40	.40	.00	175.	1.02	18.50	257	0.00	0.00	0.00	0.
1.01	18.00	108	.40	.40	.00	175.	1.02	19.00	258	0.00	0.00	0.00	0.
1.01	18.10	109	.04	.04	.00	128.	1.02	19.10	259	0.00	0.00	0.00	0.
1.01	18.20	110	.04	.04	.00	117.	1.02	19.20	260	0.00	0.00	0.00	0.
1.01	18.30	111	.04	.04	.00	107.	1.02	19.30	261	0.00	0.00	0.00	0.
1.01	18.40	112	.04	.04	.00	98.	1.02	19.40	262	0.00	0.00	0.00	0.
1.01	18.50	113	.04	.04	.00	87.	1.02	19.50	263	0.00	0.00	0.00	0.
1.01	19.00	114	.04	.04	.00	81.	1.02	20.00	264	0.00	0.00	0.00	0.
1.01	19.10	115	.04	.04	.00	74.	1.02	20.10	265	0.00	0.00	0.00	0.

1.01	19.20	116	.04	.04	.00	68.	1.02	20.20	266	0.00	0.00	0.00	0.
1.01	19.30	117	.04	.04	.00	62.	1.02	20.30	267	0.00	0.00	0.00	0.
1.01	19.40	118	.04	.04	.00	56.	1.02	20.40	268	0.00	0.00	0.00	0.
1.01	19.50	119	.04	.04	.00	51.	1.02	20.50	269	0.00	0.00	0.00	0.
1.01	20.00	120	.04	.04	.00	47.	1.02	21.00	270	0.00	0.00	0.00	0.
1.01	20.10	121	.04	.04	.00	43.	1.02	21.10	271	0.00	0.00	0.00	0.
1.01	20.20	122	.04	.04	.00	39.	1.02	21.20	272	0.00	0.00	0.00	0.
1.01	20.30	123	.04	.04	.00	36.	1.02	21.30	273	0.00	0.00	0.00	0.
1.01	20.40	124	.04	.04	.00	32.	1.02	21.40	274	0.00	0.00	0.00	0.
1.01	20.50	125	.04	.04	.00	30.	1.02	21.50	275	0.00	0.00	0.00	0.
1.01	21.00	126	.04	.04	.00	27.	1.02	22.00	276	0.00	0.00	0.00	0.
1.01	21.10	127	.04	.04	.00	25.	1.02	22.10	277	0.00	0.00	0.00	0.
1.01	21.20	128	.04	.04	.00	23.	1.02	22.20	278	0.00	0.00	0.00	0.
1.01	21.30	129	.04	.04	.00	21.	1.02	22.30	279	0.00	0.00	0.00	0.
1.01	21.40	130	.04	.04	.00	19.	1.02	22.40	280	0.00	0.00	0.00	0.
1.01	21.50	131	.04	.04	.00	17.	1.02	22.50	281	0.00	0.00	0.00	0.
1.01	22.00	132	.04	.04	.00	16.	1.02	23.00	282	0.00	0.00	0.00	0.
1.01	22.10	133	.04	.04	.00	16.	1.02	23.10	283	0.00	0.00	0.00	0.
1.01	22.20	134	.04	.04	.00	16.	1.02	23.20	284	0.00	0.00	0.00	0.
1.01	22.30	135	.04	.04	.00	16.	1.02	23.30	285	0.00	0.00	0.00	0.
1.01	22.40	136	.04	.04	.00	16.	1.02	23.40	286	0.00	0.00	0.00	0.
1.01	22.50	137	.04	.04	.00	16.	1.02	23.50	287	0.00	0.00	0.00	0.
1.01	23.00	138	.04	.04	.00	16.	1.03	0.00	288	0.00	0.00	0.00	0.
1.01	23.10	139	.04	.04	.00	16.	1.03	.10	289	0.00	0.00	0.00	0.
1.01	23.20	140	.04	.04	.00	16.	1.03	.20	290	0.00	0.00	0.00	0.
1.01	23.30	141	.04	.04	.00	16.	1.03	.30	291	0.00	0.00	0.00	0.
1.01	23.40	142	.04	.04	.00	16.	1.03	.40	292	0.00	0.00	0.00	0.
1.01	23.50	143	.04	.04	.00	16.	1.03	.50	293	0.00	0.00	0.00	0.
1.02	0.00	144	.04	.04	.00	16.	1.03	1.00	294	0.00	0.00	0.00	0.
1.02	.10	145	0.00	0.00	0.00	14.	1.03	1.10	295	0.00	0.00	0.00	0.
1.02	.20	146	0.00	0.00	0.00	13.	1.03	1.20	296	0.00	0.00	0.00	0.
1.02	.30	147	0.00	0.00	0.00	12.	1.03	1.30	297	0.00	0.00	0.00	0.
1.02	.40	148	0.00	0.00	0.00	11.	1.03	1.40	298	0.00	0.00	0.00	0.
1.02	.50	149	0.00	0.00	0.00	10.	1.03	1.50	299	0.00	0.00	0.00	0.
1.02	1.00	150	0.00	0.00	0.00	9.	1.03	2.00	300	0.00	0.00	0.00	0.
									SUM	28.13	26.98	1.15	12746.
										(714.)(	685.)(	29.)(	360.91)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1366.	263.	88.	42.	12740.
CMS	39.	7.	2.	1.	361.
INCHES		21.84	29.26	29.33	29.39
MM		554.68	743.19	744.99	746.57
AC-FT		130.	175.	175.	175.
THOUS CU M		161.	215.	216.	216.

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SUB-AREA RUNOFF COMPUTATION

FLOW FROM BASIN AREA ABOVE RAILROAD EMBANKMENT

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
RPDIS	0	0	0	1	1	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	0.00	0.00	0.00	1.00	0.000	0	0	0

INPUT HYDROGRAPH

1.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	1.	1.	1.	1.	1.	1.	1.
1.	2.	2.	2.	2.	3.	3.	3.	4.	4.
5.	6.	6.	8.	9.	11.	13.	15.	16.	18.
20.	22.	25.	28.	31.	33.	36.	39.	42.	44.
46.	49.	51.	52.	54.	55.	57.	58.	59.	61.
62.	63.	65.	66.	68.	71.	74.	78.	82.	86.
88.	91.	94.	97.	101.	104.	108.	110.	111.	113.
114.	115.	117.	118.	120.	122.	160.	248.	282.	260.
215.	167.	132.	123.	123.	122.	121.	121.	120.	120.
117.	119.	118.	117.	116.	115.	114.	114.	113.	112.
112.	112.	111.	111.	110.	110.	110.	110.	109.	109.
109.	108.	108.	108.	108.	108.	108.	108.	108.	108.
107.	107.	107.	107.	106.	106.	106.	106.	105.	105.
104.	104.	103.	103.	103.	102.	102.	102.	102.	102.
101.	101.	100.	99.	98.	98.	97.	97.	97.	96.
96.	96.	96.	95.	95.	94.	94.	93.	93.	93.
92.	92.	91.	91.	90.	90.	90.	89.	89.	88.
88.	87.	87.	87.	86.	86.	85.	85.	84.	83.
83.	82.	81.	80.	80.	79.	78.	78.	77.	76.
76.	75.	74.	73.	73.	72.	71.	71.	70.	70.
69.	68.	67.	66.	66.	65.	64.	63.	63.	62.
61.	61.	60.	59.	58.	58.	57.	56.	56.	55.
54.	54.	53.	52.	51.	51.	50.	49.	48.	47.
46.	45.	44.	43.	42.	41.	40.	39.	38.	37.
36.	36.	35.	34.	33.	32.	31.	31.	30.	29.
28.	27.	27.	26.	25.	25.	24.	23.	22.	22.
22.	21.	21.	20.	20.	20.	19.	19.	19.	18.
18.	18.	17.	17.	17.	16.	16.	16.	16.	15.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	282.	135.	104.	65.	19531.
CMS	8.	4.	3.	2.	553.
INCHES		.00	.00	.00	.00
MM		.00	.00	.00	.00
AC-FT		67.	207.	269.	269.
THOUS CU M		82.	255.	332.	332.

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                                          HYDROGRAPH ROUTING

                          FLOOD ROUTING THROUGH ORIGIONAL TAILINGS DAM POND

                                ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                                 LAKE        1        0        0        1        1        1        0        0
                                                       ROUTING DATA
                         QLOSS   CLOSS      AVG     IRES    ISAME     IOPT     IPMP                LSTR
                           0.0   0.000     0.00        1        0        0        0                   0

                                NSTPS    NSTDL      LAG    AMSKK        X      TSK    STORA   ISPRAT
                                    1        0        0    0.000    0.000    0.000    -893.       -1

  STAGE      901.70      902.09      902.25      902.50      902.75      903.00

   FLOW        0.00       13.30       54.70      121.50      213.90      333.20

SURFACE AREA=       0.          8.         48.        100.        151.

   CAPACITY=        0.          8.        336.       1060.       2304.

  ELEVATION=      884.        887.        900.        910.        920.

                               CREL    SPWID     COQW     EXPW    ELEVL     COQL    CAREA     EXPL
                              901.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0

                                                           DAM DATA
                                                 TOPEL     COQD     EXPD   DAMWID
                                                 901.7      0.0      0.0       0.
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00
HYDROGRAPH AT	INFL	.11 (.29)	1 (	1364. 38.62)(
HYDROGRAPH AT	KROTS	0.00 (0.00)	1 (	282. 7.99)(
2 COMBINED	TOTFN	.11 (.29)	1 (	1482. 41.96)(
ROUTED TO	LAKE	.11 (.29)	1 (	75. 2.13)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

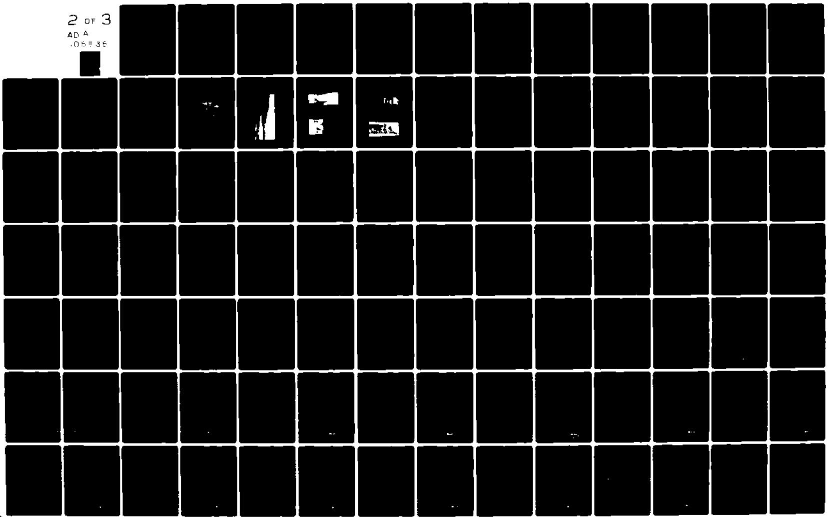
	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	893.20	901.70	901.70
STORAGE	100.	423.	423.
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	902.33	.63	459.	75.	24.00	35.33	0.00

AD-A105 535 INTERNATIONAL ENGINEERING CO INC SAN FRANCISCO CA F/G 13/13
NATIONAL DAM SAFETY PROGRAM. ST. JOE STATE PARK DAM (MO 30277),--ETC(U)
FEB 80 K B KING, S H KLINE, J H GRAY DACW43-79-C-0037

UNCLASSIFIED NL

2 OF 3
AD A
105535



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A1          ST JOE STATE PARK ORIGIONAL DAM  (MISSOURI)        NO. 30277
A2          HECI PHASE 1 DAM SAFETY INVESTIGATIONS
A3          PMF (100%) ROUTED THROUGH SPILLWAY AND OVER DAM TOP                SH-34
B     300        0        10        0        0        0        0        0        0        0
B1      5
J       1        1         1
J1    1.0
K       0     INFL                                    1        1
K1               PMF LOCAL  INFLOW TO TAILINGS DAM POND
M       1        2     0.112                          1
P       0     26.6       102      120      130
T                                                             -1      -91
W2            0.080
X     -10     -0.1       2.5
K       0     RRDIS                          1        1        1
K1          FLOW FROM BASIN AREA ABOVE RAILROAD EMBANKMENT
M      -1                                             1
N       1        2         2        2        2        2        2        2        2        2
N       2        2         2        2        2        2        2        2        2        2
N       2        2         2        2        2        2        2        2        2        2
N       2        2         2        2        3        3        3        4        4        5
N       5        6         8        9       11       13       15       18       20       22
N      25       29        32       36       39       42       45       48       51       53
N      54       56        58       60       61       63       65       66       68       69
N      71       72        74       76       78       81       84       87       90       93
N      97      101       104      108      110      112      113      115      116      118
N     119      119       120      121      123      195      345      495      517      440
N     340      271       214      170      139      124      123      122      122      121
N     121      120       119      118      117      116      115      115      114      113
N     113      112       112      111      111      111      111      110      110      110
N     110      110       110      109      109      109      108      108      108      108
N     108      108       108      108      108      108      108      108      108      108
N     108      108       107      107      105      105      104      104      103      103
N     102      102       102      101      101      100      100       99       99       98
N      98       97        97       96       96       95       95       95       95       94
```

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N       94      93      93      93      92      92      91      91      90      90
N       90      89      89      88      88      87      87      86      86      86
N       85      84      84      83      82      82      81      80      80      79
N       78      77      77      76      75      75      74      73      73      72
N       71      71      70      69      68      68      67      66      66      65
N       64      63      63      62      61      60      60      59      58      58
N       57      56      56      55      54      53      53      52      51      51
N       50      49      48      47      46      45      44      43      42      41
N       40      39      38      37      36      35      35      34      33      32
N       31      30      30      29      28      27      27      26      25      24
N       24      23      22      22      21      21      21      20      20      20
N       19      19      19      18      18      18      17      17      17      16
K        2  TOTIN                            1       1       1
KI              TOTAL INFLOW TO TAILINGS DAM POND
K        1   LAKE                            1       1       1

KI          FLOOD ROUTING THROUGH ORIGIONAL TAILINGS DAM POND
Y                                    1
Y1       1                                               -893.2      -1
Y4   901.7   902.0  902.25   902.5  902.75   903.0
Y5       0    13.3    54.7   121.5   213.9   333.2
$A       0       8      48     100   150.6
$E     884     887     900     910     920
$$   901.7
$D   901.7
K       99
```

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********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  26 FEB 79
********************************

RUN  DATE* 80/01/31.
     TIME* 12.24.09.


               ST JOE STATE PARK ORIGIONAL DAM  (MISSOURI)        NO. 30277
               HECI PHASE 1 DAM SAFETY INVESTIGATIONS
               PMF (100%) ROUTED THROUGH SPILLWAY AND OVER DAM TOP           SH-34

                                 JOB SPECIFICATION
      NQ      NHR     NMIN     IDAY      IHR     IMIN    METRC     IPLT     IPRT    NSTAN
     300        0       10        0        0        0        0        0        0        0
                              JOPER      NWT    LROPT    TRACE
                                  5        0        0        0

                     MULTI-PLAN ANALYSES TO BE PERFORMED
                        NPLAN= 1 NRTIO= 1 LRTIO= 1
     RTIOS=   1.00


  **********     **********     **********     **********     **********

                      SUB-AREA RUNOFF COMPUTATION

            PMF LOCAL INFLOW TO TAILINGS DAM POND

             ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
              INFL       0       0       0       0       1       1       0       0

                              HYDROGRAPH DATA
     IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
         1       2     .11    0.00     .11    1.00   0.000       0       0       0

                                PRECIP DATA
              SPFE     PMS      R6     R12     R24     R48     R72     R96
              0.00   26.60  102.00  120.00  130.00    0.00    0.00    0.00

                                 LOSS DATA
   LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
       0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -91.00    0.00    0.00

     CURVE NO =  -91.00   WETNESS =   -1.00  EFFECT CN =   91.00

                           UNIT HYDROGRAPH DATA
                          TC=  0.00    LAG=   .08

                              RECESSION DATA
                  STRTQ=  -10.00    ORCSN=    -.10    RTIOR= 2.50

     TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

     UNIT HYDROGRAPH  5 END-OF-PERIOD ORDINATES, TC=    0.00 HOURS, LAG=    .08  VOL= 1.00
```

322. 90. 18. 4. 0.

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.03	0.00	.03	1.	1.02	1.10	151	0.00	0.00	0.00	10.
1.01	.20	2	.03	0.00	.03	1.	1.02	1.20	152	0.00	0.00	0.00	9.
1.01	.30	3	.03	0.00	.03	1.	1.02	1.30	153	0.00	0.00	0.00	8.
1.01	.40	4	.03	0.00	.03	1.	1.02	1.40	154	0.00	0.00	0.00	8.
1.01	.50	5	.03	0.00	.03	1.	1.02	1.50	155	0.00	0.00	0.00	7.
1.01	1.00	6	.03	0.00	.03	1.	1.02	2.00	156	0.00	0.00	0.00	6.
1.01	1.10	7	.03	.00	.03	1.	1.02	2.10	157	0.00	0.00	0.00	6.
1.01	1.20	8	.03	.00	.03	1.	1.02	2.20	158	0.00	0.00	0.00	5.
1.01	1.30	9	.03	.00	.03	2.	1.02	2.30	159	0.00	0.00	0.00	5.
1.01	1.40	10	.03	.00	.03	2.	1.02	2.40	160	0.00	0.00	0.00	4.
1.01	1.50	11	.03	.01	.02	3.	1.02	2.50	161	0.00	0.00	0.00	4.
1.01	2.00	12	.03	.01	.02	3.	1.02	3.00	162	0.00	0.00	0.00	4.
1.01	2.10	13	.03	.01	.02	4.	1.02	3.10	163	0.00	0.00	0.00	3.
1.01	2.20	14	.03	.01	.02	4.	1.02	3.20	164	0.00	0.00	0.00	3.
1.01	2.30	15	.03	.01	.02	5.	1.02	3.30	165	0.00	0.00	0.00	3.
1.01	2.40	16	.03	.01	.02	5.	1.02	3.40	166	0.00	0.00	0.00	3.
1.01	2.50	17	.03	.01	.02	5.	1.02	3.50	167	0.00	0.00	0.00	2.
1.01	3.00	18	.03	.01	.02	6.	1.02	4.00	168	0.00	0.00	0.00	2.
1.01	3.10	19	.03	.01	.02	6.	1.02	4.10	169	0.00	0.00	0.00	2.
1.01	3.20	20	.03	.01	.02	6.	1.02	4.20	170	0.00	0.00	0.00	2.
1.01	3.30	21	.03	.01	.01	6.	1.02	4.30	171	0.00	0.00	0.00	2.
1.01	3.40	22	.03	.02	.01	7.	1.02	4.40	172	0.00	0.00	0.00	1.
1.01	3.50	23	.03	.02	.01	7.	1.02	4.50	173	0.00	0.00	0.00	1.
1.01	4.00	24	.03	.02	.01	7.	1.02	5.00	174	0.00	0.00	0.00	1.
1.01	4.10	25	.03	.02	.01	7.	1.02	5.10	175	0.00	0.00	0.00	1.
1.01	4.20	26	.03	.02	.01	8.	1.02	5.20	176	0.00	0.00	0.00	1.
1.01	4.30	27	.03	.02	.01	8.	1.02	5.30	177	0.00	0.00	0.00	1.
1.01	4.40	28	.03	.02	.01	8.	1.02	5.40	178	0.00	0.00	0.00	1.
1.01	4.50	29	.03	.02	.01	8.	1.02	5.50	179	0.00	0.00	0.00	1.
1.01	5.00	30	.03	.02	.01	8.	1.02	6.00	180	0.00	0.00	0.00	1.
1.01	5.10	31	.03	.02	.01	8.	1.02	6.10	181	0.00	0.00	0.00	1.
1.01	5.20	32	.03	.02	.01	9.	1.02	6.20	182	0.00	0.00	0.00	1.
1.01	5.30	33	.03	.02	.01	9.	1.02	6.30	183	0.00	0.00	0.00	1.
1.01	5.40	34	.03	.02	.01	9.	1.02	6.40	184	0.00	0.00	0.00	0.
1.01	5.50	35	.03	.02	.01	9.	1.02	6.50	185	0.00	0.00	0.00	0.
1.01	6.00	36	.03	.02	.01	9.	1.02	7.00	186	0.00	0.00	0.00	0.
1.01	6.10	37	.13	.10	.04	34.	1.02	7.10	187	0.00	0.00	0.00	0.
1.01	6.20	38	.13	.10	.03	42.	1.02	7.20	188	0.00	0.00	0.00	0.
1.01	6.30	39	.13	.11	.03	45.	1.02	7.30	189	0.00	0.00	0.00	0.
1.01	6.40	40	.13	.11	.02	47.	1.02	7.40	190	0.00	0.00	0.00	0.
1.01	6.50	41	.13	.11	.02	48.	1.02	7.50	191	0.00	0.00	0.00	0.
1.01	7.00	42	.13	.11	.02	49.	1.02	8.00	192	0.00	0.00	0.00	0.
1.01	7.10	43	.13	.12	.02	50.	1.02	8.10	193	0.00	0.00	0.00	0.
1.01	7.20	44	.13	.12	.02	51.	1.02	8.20	194	0.00	0.00	0.00	0.
1.01	7.30	45	.13	.12	.01	51.	1.02	8.30	195	0.00	0.00	0.00	0.
1.01	7.40	46	.13	.12	.01	52.	1.02	8.40	196	0.00	0.00	0.00	0.
1.01	7.50	47	.13	.12	.01	52.	1.02	8.50	197	0.00	0.00	0.00	0.
1.01	8.00	48	.13	.12	.01	53.	1.02	9.00	198	0.00	0.00	0.00	0.
1.01	8.10	49	.13	.12	.01	53.	1.02	9.10	199	0.00	0.00	0.00	0.
1.01	8.20	50	.13	.12	.01	53.	1.02	9.20	200	0.00	0.00	0.00	0.
1.01	8.30	51	.13	.12	.01	54.	1.02	9.30	201	0.00	0.00	0.00	0.
1.01	8.40	52	.13	.12	.01	54.	1.02	9.40	202	0.00	0.00	0.00	0.
1.01	8.50	53	.13	.11	.01	54.	1.02	9.50	203	0.00	0.00	0.00	0.
1.01	9.00	54	.13	.11	.01	54.	1.02	10.00	204	0.00	0.00	0.00	0.
1.01	9.10	55	.13	.11	.01	55.	1.02	10.10	205	0.00	0.00	0.00	0.

1.01	9.20	56	.13	.13	.01	55.
1.01	9.30	57	.13	.13	.01	55.
1.01	9.40	58	.13	.13	.01	55.
1.01	9.50	59	.13	.13	.01	55.
1.01	10.00	60	.13	.13	.01	55.
1.01	10.10	61	.13	.13	.00	55.
1.01	10.20	62	.13	.13	.00	56.
1.01	10.30	63	.13	.13	.00	56.
1.01	10.40	64	.13	.13	.00	56.
1.01	10.50	65	.13	.13	.00	56.
1.01	11.00	66	.13	.13	.00	56.
1.01	11.10	67	.13	.13	.00	56.
1.01	11.20	68	.13	.13	.00	56.
1.01	11.30	69	.13	.13	.00	56.
1.01	11.40	70	.13	.13	.00	56.
1.01	11.50	71	.13	.13	.00	56.
1.01	12.00	72	.13	.13	.00	56.
1.01	12.10	73	.45	.44	.01	157.
1.01	12.20	74	.45	.44	.01	186.
1.01	12.30	75	.45	.44	.01	192.
1.01	12.40	76	.45	.45	.01	193.
1.01	12.50	77	.45	.45	.01	193.
1.01	13.00	78	.45	.45	.01	194.
1.01	13.10	79	.54	.54	.01	223.
1.01	13.20	80	.54	.54	.01	231.
1.01	13.30	81	.54	.54	.00	233.
1.01	13.40	82	.54	.54	.00	233.
1.01	13.50	83	.54	.54	.00	233.
1.01	14.00	84	.54	.54	.00	234.
1.01	14.10	85	.68	.67	.00	277.
1.01	14.20	86	.68	.67	.00	290.
1.01	14.30	87	.68	.68	.00	292.
1.01	14.40	88	.68	.68	.00	293.
1.01	14.50	89	.68	.68	.00	293.
1.01	15.00	90	.68	.68	.00	293.
1.01	15.10	91	.62	.62	.00	274.
1.01	15.20	92	1.03	1.03	.00	401.
1.01	15.30	93	1.86	1.85	.00	702.
1.01	15.40	94	4.64	4.63	.01	1678.
1.01	15.50	95	1.34	1.34	.00	885.
1.01	16.00	96	.82	.82	.00	474.
1.01	16.10	97	.63	.63	.00	318.
1.01	16.20	98	.63	.63	.00	280.
1.01	16.30	99	.63	.63	.00	275.
1.01	16.40	100	.63	.63	.00	274.
1.01	16.50	101	.63	.63	.00	274.
1.01	17.00	102	.63	.63	.00	274.
1.01	17.10	103	.50	.50	.00	230.
1.01	17.20	104	.50	.50	.00	216.
1.01	17.30	105	.50	.50	.00	216.
1.01	17.40	106	.50	.50	.00	215.
1.01	17.50	107	.50	.50	.00	215.
1.01	18.00	108	.50	.50	.00	215.
1.01	18.10	109	.04	.04	.00	154.
1.01	18.20	110	.04	.04	.00	144.
1.01	18.30	111	.04	.04	.00	131.
1.01	18.40	112	.04	.04	.00	120.
1.01	18.50	113	.04	.04	.00	107.
1.01	19.00	114	.04	.04	.00	100.
1.01	19.10	115	.04	.04	.00	91.

1.02	10.20	206	0.00	0.00	0.00	0.
1.02	10.30	207	0.00	0.00	0.00	0.
1.02	10.40	208	0.00	0.00	0.00	0.
1.02	10.50	209	0.00	0.00	0.00	0.
1.02	11.00	210	0.00	0.00	0.00	0.
1.02	11.10	211	0.00	0.00	0.00	0.
1.02	11.20	212	0.00	0.00	0.00	0.
1.02	11.30	213	0.00	0.00	0.00	0.
1.02	11.40	214	0.00	0.00	0.00	0.
1.02	11.50	215	0.00	0.00	0.00	0.
1.02	12.00	216	0.00	0.00	0.00	0.
1.02	12.10	217	0.00	0.00	0.00	0.
1.02	12.20	218	0.00	0.00	0.00	0.
1.02	12.30	219	0.00	0.00	0.00	0.
1.02	12.40	220	0.00	0.00	0.00	0.
1.02	12.50	221	0.00	0.00	0.00	0.
1.02	13.00	222	0.00	0.00	0.00	0.
1.02	13.10	223	0.00	0.00	0.00	0.
1.02	13.20	224	0.00	0.00	0.00	0.
1.02	13.30	225	0.00	0.00	0.00	0.
1.02	13.40	226	0.00	0.00	0.00	0.
1.02	13.50	227	0.00	0.00	0.00	0.
1.02	14.00	228	0.00	0.00	0.00	0.
1.02	14.10	229	0.00	0.00	0.00	0.
1.02	14.20	230	0.00	0.00	0.00	0.
1.02	14.30	231	0.00	0.00	0.00	0.
1.02	14.40	232	0.00	0.00	0.00	0.
1.02	14.50	233	0.00	0.00	0.00	0.
1.02	15.00	234	0.00	0.00	0.00	0.
1.02	15.10	235	0.00	0.00	0.00	0.
1.02	15.20	236	0.00	0.00	0.00	0.
1.02	15.30	237	0.00	0.00	0.00	0.
1.02	15.40	238	0.00	0.00	0.00	0.
1.02	15.50	239	0.00	0.00	0.00	0.
1.02	16.00	240	0.00	0.00	0.00	0.
1.02	16.10	241	0.00	0.00	0.00	0.
1.02	16.20	242	0.00	0.00	0.00	0.
1.02	16.30	243	0.00	0.00	0.00	0.
1.02	16.40	244	0.00	0.00	0.00	0.
1.02	16.50	245	0.00	0.00	0.00	0.
1.02	17.00	246	0.00	0.00	0.00	0.
1.02	17.10	247	0.00	0.00	0.00	0.
1.02	17.20	248	0.00	0.00	0.00	0.
1.02	17.30	249	0.00	0.00	0.00	0.
1.02	17.40	250	0.00	0.00	0.00	0.
1.02	17.50	251	0.00	0.00	0.00	0.
1.02	18.00	252	0.00	0.00	0.00	0.
1.02	18.10	253	0.00	0.00	0.00	0.
1.02	18.20	254	0.00	0.00	0.00	0.
1.02	18.30	255	0.00	0.00	0.00	0.
1.02	18.40	256	0.00	0.00	0.00	0.
1.02	18.50	257	0.00	0.00	0.00	0.
1.02	19.00	258	0.00	0.00	0.00	0.
1.02	19.10	259	0.00	0.00	0.00	0.
1.02	19.20	260	0.00	0.00	0.00	0.
1.02	19.30	261	0.00	0.00	0.00	0.
1.02	19.40	262	0.00	0.00	0.00	0.
1.02	19.50	263	0.00	0.00	0.00	0.
1.02	20.00	264	0.00	0.00	0.00	0.
1.02	20.10	265	0.00	0.00	0.00	0.

1.01	19.20	116	.04	.04	.00	83.		1.02	20.20	266	0.00	0.00	0.00	0.
1.01	19.30	117	.04	.04	.00	76.		1.02	20.30	267	0.00	0.00	0.00	0.
1.01	19.40	118	.04	.04	.00	69.		1.02	20.40	268	0.00	0.00	0.00	0.
1.01	19.50	119	.04	.04	.00	63.		1.02	20.50	269	0.00	0.00	0.00	0.
1.01	20.00	120	.04	.04	.00	58.		1.02	21.00	270	0.00	0.00	0.00	0.
1.01	20.10	121	.04	.04	.00	53.		1.02	21.10	271	0.00	0.00	0.00	0.
1.01	20.20	122	.04	.04	.00	48.		1.02	21.20	272	0.00	0.00	0.00	0.
1.01	20.30	123	.04	.04	.00	44.		1.02	21.30	273	0.00	0.00	0.00	0.
1.01	20.40	124	.04	.04	.00	40.		1.02	21.40	274	0.00	0.00	0.00	0.
1.01	20.50	125	.04	.04	.00	36.		1.02	21.50	275	0.00	0.00	0.00	0.
1.01	21.00	126	.04	.04	.00	33.		1.02	22.00	276	0.00	0.00	0.00	0.
1.01	21.10	127	.04	.04	.00	30.		1.02	22.10	277	0.00	0.00	0.00	0.
1.01	21.20	128	.04	.04	.00	28.		1.02	22.20	278	0.00	0.00	0.00	0.
1.01	21.30	129	.04	.04	.00	25.		1.02	22.30	279	0.00	0.00	0.00	0.
1.01	21.40	130	.04	.04	.00	23.		1.02	22.40	280	0.00	0.00	0.00	0.
1.01	21.50	131	.04	.04	.00	21.		1.02	22.50	281	0.00	0.00	0.00	0.
1.01	22.00	132	.04	.04	.00	19.		1.02	23.00	282	0.00	0.00	0.00	0.
1.01	22.10	133	.04	.04	.00	19.		1.02	23.10	283	0.00	0.00	0.00	0.
1.01	22.20	134	.04	.04	.00	19.		1.02	23.20	284	0.00	0.00	0.00	0.
1.01	22.30	135	.04	.04	.00	19.		1.02	23.30	285	0.00	0.00	0.00	0.
1.01	22.40	136	.04	.04	.00	19.		1.02	23.40	286	0.00	0.00	0.00	0.
1.01	22.50	137	.04	.04	.00	19.		1.02	23.50	287	0.00	0.00	0.00	0.
1.01	23.00	138	.04	.04	.00	19.		1.03	0.00	288	0.00	0.00	0.00	0.
1.01	23.10	139	.04	.04	.00	19.		1.03	.10	289	0.00	0.00	0.00	0.
1.01	23.20	140	.04	.04	.00	19.		1.03	.20	290	0.00	0.00	0.00	0.
1.01	23.30	141	.04	.04	.00	19.		1.03	.30	291	0.00	0.00	0.00	0.
1.01	23.40	142	.04	.04	.00	19.		1.03	.40	292	0.00	0.00	0.00	0.
1.01	23.50	143	.04	.04	.00	19.		1.03	.50	293	0.00	0.00	0.00	0.
1.02	0.00	144	.04	.04	.00	19.		1.03	1.00	294	0.00	0.00	0.00	0.
1.02	.10	145	0.00	0.00	0.00	18.		1.03	1.10	295	0.00	0.00	0.00	0.
1.02	.20	146	0.00	0.00	0.00	16.		1.03	1.20	296	0.00	0.00	0.00	0.
1.02	.30	147	0.00	0.00	0.00	15.		1.03	1.30	297	0.00	0.00	0.00	0.
1.02	.40	148	0.00	0.00	0.00	13.		1.03	1.40	298	0.00	0.00	0.00	0.
1.02	.50	149	0.00	0.00	0.00	12.		1.03	1.50	299	0.00	0.00	0.00	0.
1.02	1.00	150	0.00	0.00	0.00	11.		1.03	2.00	300	0.00	0.00	0.00	0.

SUM 36.58 33.42 1.16 15766.
(929.)(849.)(29.)(446.44)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1678.	324.	109.	53.	15773.
CMS	48.	9.	3.	1.	447.
INCHES		26.90	36.21	36.39	36.39
MM		683.25	919.67	924.28	924.28
AC-FT		161.	216.	217.	217.
THOUS CU M		198.	267.	268.	268.

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

FLOW FROM BASIN AREA ABOVE RAILROAD EMBANKMENT

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
RRDIS	0	0	0	1	1	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	0.00	0.00	0.00	1.00	0.000	0	0	0

INPUT HYDROGRAPH

1.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	3.	3.	3.	4.	4.	5.
5.	6.	8.	9.	11.	13.	15.	18.	20.	22.
25.	29.	32.	36.	39.	42.	45.	48.	51.	53.
54.	56.	58.	60.	61.	63.	65.	66.	68.	69.
71.	72.	74.	76.	78.	81.	84.	87.	90.	93.
97.	101.	104.	108.	110.	112.	113.	115.	116.	118.
119.	119.	120.	121.	123.	195.	345.	495.	517.	440.
340.	271.	214.	170.	139.	124.	123.	122.	122.	121.
121.	120.	119.	118.	117.	116.	115.	115.	114.	113.
113.	112.	112.	111.	111.	111.	111.	110.	110.	110.
110.	110.	110.	109.	109.	109.	108.	108.	108.	108.
108.	108.	108.	108.	108.	108.	108.	108.	108.	108.
108.	108.	107.	107.	105.	105.	104.	104.	103.	103.
102.	102.	102.	101.	101.	100.	100.	99.	99.	98.
98.	97.	97.	96.	96.	95.	95.	95.	95.	94.
94.	93.	93.	93.	92.	92.	91.	91.	90.	90.
90.	89.	89.	88.	88.	87.	87.	86.	86.	86.
85.	84.	84.	83.	82.	82.	81.	80.	80.	79.
78.	77.	77.	76.	75.	75.	74.	73.	73.	72.
71.	71.	70.	69.	68.	68.	67.	66.	66.	65.
64.	63.	63.	62.	61.	60.	60.	59.	58.	58.
57.	56.	56.	55.	54.	53.	53.	52.	51.	51.
50.	49.	48.	47.	46.	45.	44.	43.	42.	41.
40.	39.	38.	37.	36.	35.	35.	34.	33.	32.
31.	30.	30.	29.	28.	27.	27.	26.	25.	24.
24.	23.	22.	22.	21.	21.	21.	20.	20.	20.
19.	19.	19.	18.	18.	18.	17.	17.	17.	16.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	517.	172.	116.	72.	21607.
CMS	15.	5.	3.	2.	612.
INCHES		.00	.00	.00	.00
MM		.00	.00	.00	.00
AC-FT		85.	229.	298.	298.
THOUS CU M		105.	283.	367.	367.

```
**********          **********          **********          **********          **********

                                   HYDROGRAPH ROUTING

                   FLOOD ROUTING THROUGH ORIGIONAL TAILINGS DAM POND

                ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                 LAKE        1        0        0        1        1        1        0        0
                                     ROUTING DATA
       QLOSS    CLOSS      AVG     IRES    ISAME     IOPT     IPMP              LSTR
         0.0    0.000     0.00        1        0        0        0                 0

                NSTPS    NSTDL      LAG    AMSKK        X      TSK    STORA   ISPRAT
                    1        0        0    0.000    0.000    0.000    -893.       -1

STAGE        901.70       902.00       902.25       902.50       902.75       903.00

FLOW           0.00        13.30        54.70       121.50       213.90       333.20

SURFACE AREA=        0.          8.         48.        100.        151.

CAPACITY=            0.          8.        336.       1060.       2304.

ELEVATION=         884.        887.        900.        910.        920.

              CREL    SPWID     COQW     EXPW     ELEVL     COQL    CAREA     EXPL
             901.7      0.0      0.0      0.0       0.0      0.0      0.0      0.0

                                        DAM DATA
                               TOPEL     COQD     EXPD   DAMWID
                               901.7      0.0      0.0       0.
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00
HYDROGRAPH AT	INFL	.11 (.29)	1	1678. (47.53)(
HYDROGRAPH AT	RROIS	0.00 (0.00)	1	517. (14.64)(
2 COMBINED	TOTEA	.11 (.29)	1	1799. (50.95)(
ROUTED TO	LAKE	.11 (.29)	1	101. (2.86)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	893.20	901.70	901.70
STORAGE	100.	423.	423.
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	902.42	.72	465.	101.	30.00	28.17	0.00

APPENDIX B

INFORMATION SUPPLIED BY OTHERS

Item	Page No.
Dunlap, M. N., "The Davis Creek Dam", American Institute of Mining and Metallurgical Engineers, Technical Publication No. 2176, March 1947.	B-1
Letter to IECO from St. Joe Minerals Corporation Describing Appurtenant Structures and Drill Hole Data at the St. Joe State Park Dam, 6 September 1979.	B-10
Geotechnical Report - St. Joe State Park, Preliminary Report to Team Four, Inc. by Sverdrup and Parcel and Associates, Inc., 10 January 1977.	B-12
Engineering Geologic Report on the St. Joe State Park Tailings Dam and Environs, by J. H. Williams, 1 March 1977.	B-20
Tailings Dam Investigation - St. Joe State Park - Flat River, Missouri, Report to State of Missouri Department of Natural Resources by Sverdrup and Parcel and Associates, Inc., January 1978.	B-24

Preprint for the New York Meeting, March 1947

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AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

Technical Publication No. 2176

Class A, Mining Technology, 1947

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented by the contributor in person at the New York Meeting, March 1947, when an abstract of the paper will be read. If this is impossible, discussion in writing (2 copies) may be sent to the Secretary, American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York 18, N. Y. Unless special arrangement is made, discussion of this paper will close April 15, 1947. Any discussion offered thereafter should preferably be in the form of a new paper.

The Davis Creek Dam

By M. N. Dunlap*

(New York Meeting, March 1947)

This article summarizes the successful incorporation of a flash-flooding stream into the tailing-disposal system at the St Joseph Lead Company's Federal Division mill, in St. Francois County, Missouri.

The mill was built in 1906, by the Federal Lead Co., as its No. 3 mill for the concentration of southeastern Missouri lead ores, and damming Davis Creek was first considered in 1908. Plans were made also in 1925 and in 1937. Dam layouts varied from a reinforced concrete structure to a barrier built of tailings alone. All were abandoned because of liability that would be incurred by flash-flood rupturing of an incompleted dam.

By 1942 mill capacity had reached 12,000 tons daily and increasing tailing-disposal costs again focused attention on the Davis Creek basin.

This time the problem of riskless dam building was solved. Moreover, most of the items that appeared in the answer were materials that normally required wasting and the major portion of labor involved performed functions that it would normally have done, without constructive benefit, elsewhere. The new layout also made possible advantageous changes in mill-water supply pumping, static head being reduced from 514 ft to 95 ft, friction head from 4000 ft to 2860 ft, and pumping can be done now at periods of low power demand. The following facts about the Davis Creek watershed explain the 36-year reluctance to reach these, and other, benefits.

- Size: 3000 acres.
- Outline: roughly pear shaped, $2\frac{1}{2}$ by 3 miles at the largest dimensions.
- Topography: mostly hill land with steep valleys.
- Relief: 760 minimum to 1153 maximum.
- Maximum rainfall: 3.36 in. per hour.
- Permanent water: none natural. Now 2200 gpm discharged through 16-in. drill hole from mine pumps underground.
- Geology: the 17 acres near dam centerline is Bonne Terre dolomite covered with sand and gravel eroded from Pleistocene beds that cap some of the hills. The remainder of the pond basin is on Davis shale.
- Soil cover: mostly second-growth timber with some abandoned fields; all subject to careless burning, which reduces water-retaining ability.
- Flood history: flash-flooding that had taken at least one life.
- Downstream values: two railroad bridges before creek intersection with Flat River. Immediately below confluence, a highway bridge, a low-water crossing, a few business establishments and several blocks of residences.

In July 1942 the following segments of an ingenious plan was put into operation.

A ditch 270 ft long, 16 ft wide and $5\frac{1}{2}$ ft deep was excavated to bedrock in the gravelly soil along the proposed dam's centerline. This excavation, which exposed many gravel-filled channels, was run full of slimes drawn from a riser set in the top of an adjacent tailings-disposal

Manuscript received at the office of the Institute May 9, 1946.

* St. Joseph Lead Co., Bonne Terre, Missouri.

Printed without author's corrections. Subject to revision.

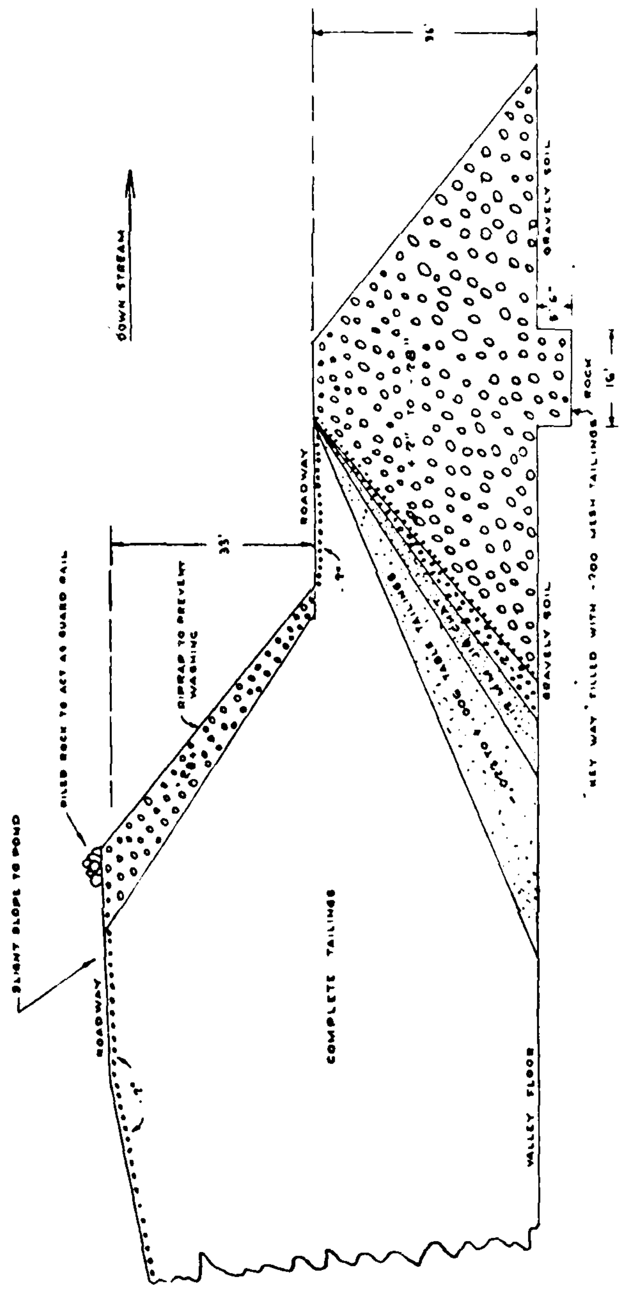


FIG. 1—GENERALIZED CROSS SECTION, DAVIS CREEK DAM.

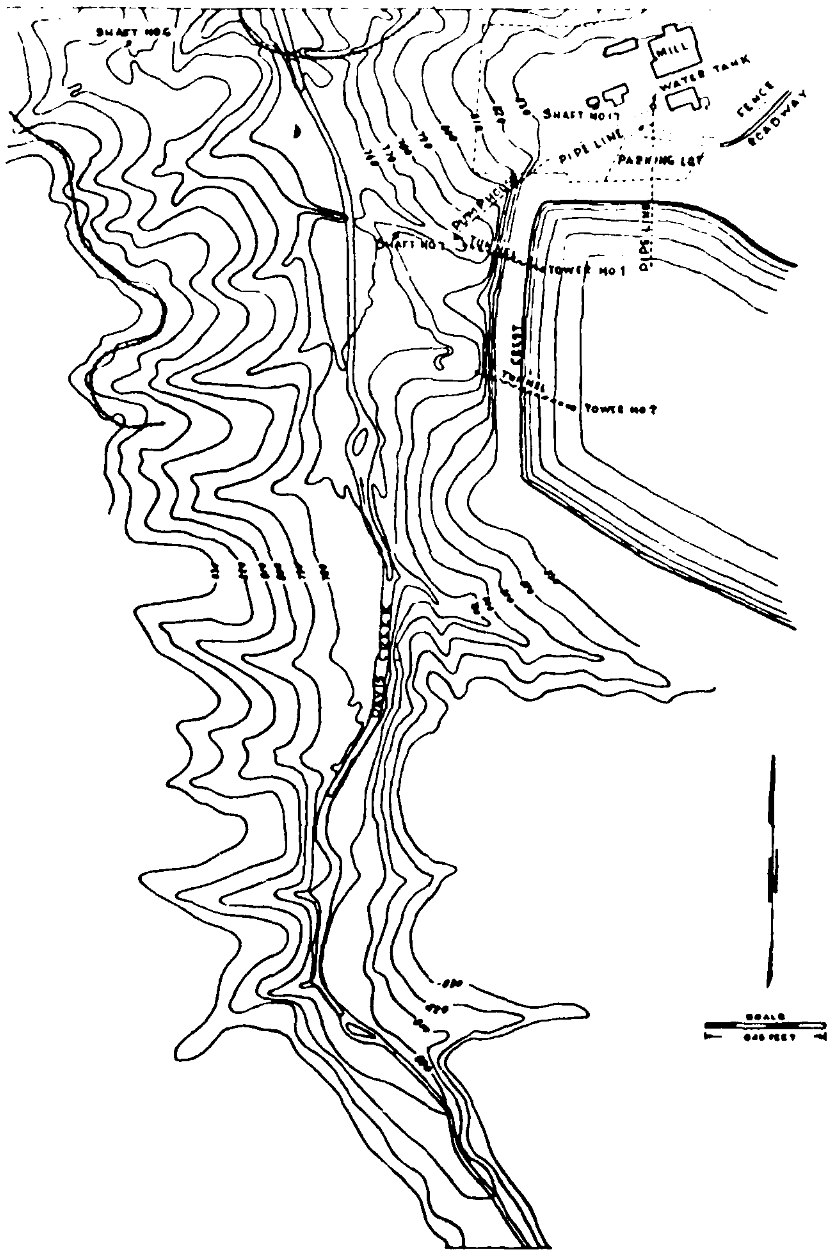


FIG 2—DAVIS CREEK SLIME POND BEFORE BUILDING OF DAM.

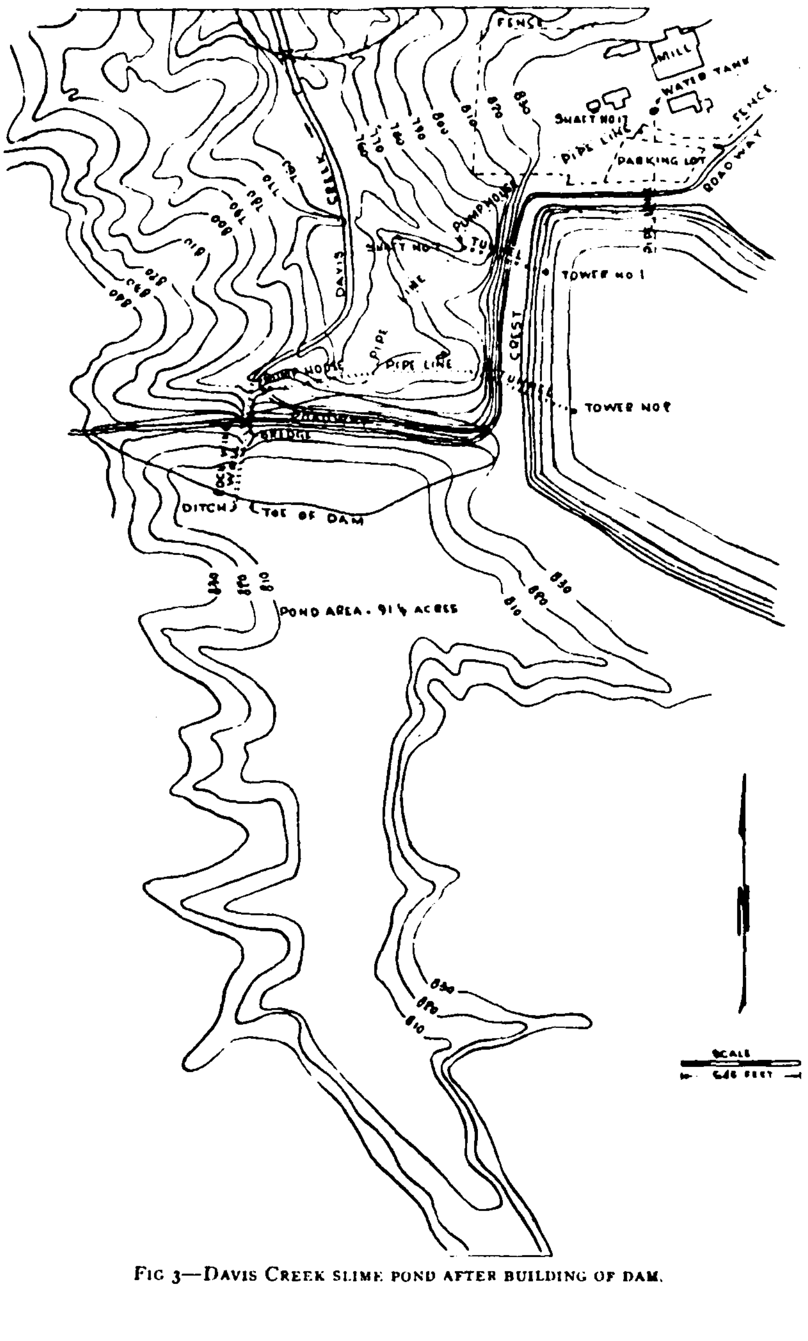


FIG 3—DAVIS CREEK SLIME POND AFTER BUILDING OF DAM.

line. Sod and debris were rooted from the residual clay that covered the remainder of the centerline.

A grizzly, with 2-in. opening, was placed in the bin at No. 12 waste-rock shaft and the plus 2-in. stone was hauled in dump trucks to the west end of the dam centerline, where it was used to make a level fill, at 797 elevation, 12 ft wide on top and 550 ft long. Maximum height was 36 ft and 24,600 cu yd of material was required. Round-trip hauling was 1¼ miles.

It was the theory that the high percentage of voids in the screened stone would not only permit a rapid escape for any impounded flood waters, but that static head and velocity would drop so rapidly within the mass that little or no rolling or washing action would be present at the fill's downstream toe. A year's rains proved the soundness of this reasoning.

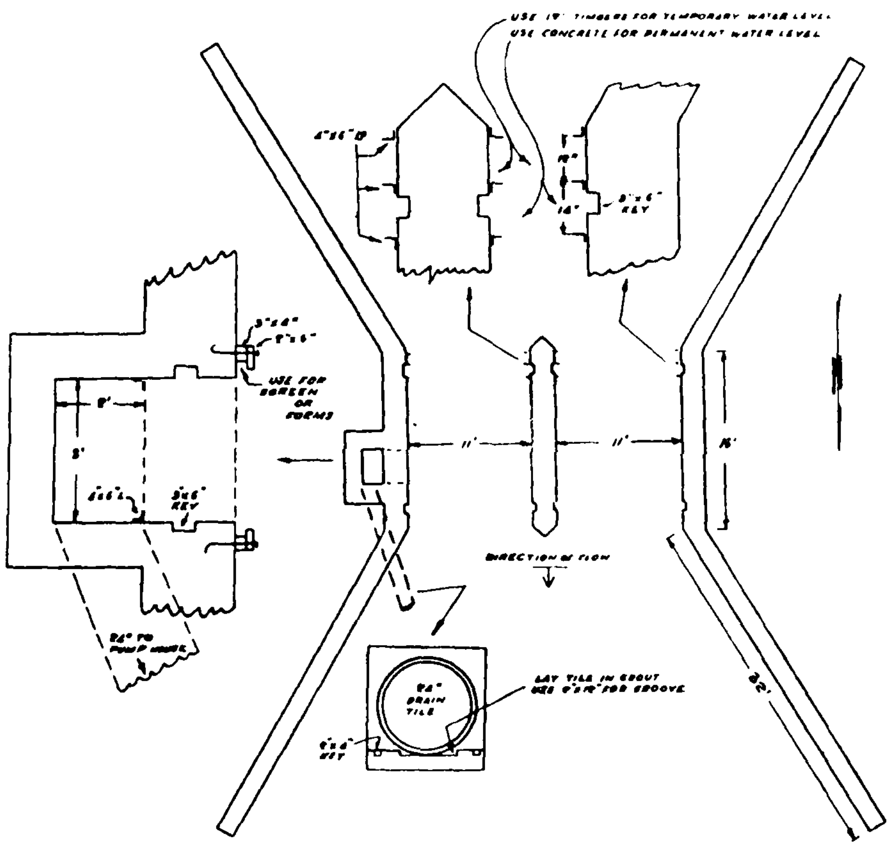


FIG 4—GENERAL PLAN, DAVIS CREEK OVERFLOW.

Sealing of the dam, which could be done whenever convenient, was delayed until the recovery-water tunnel and part of the overflow structure were concreted, but will be described now for continuity.

Minus 2-in. material was now dumped over the upstream side of the fill until all coarse rock was buried. This finer material

was in turn covered with jig chat from an old tailing pile. This sequence created a void size that increased downstream, thus ensuring a rapid decrease in static clevis made from $\frac{3}{4}$ in. rod. The bottoms of these tripod legs rest on pieces of by 12-in lumber and straddle the 10-in. pipe at approximately 40-ft intervals.

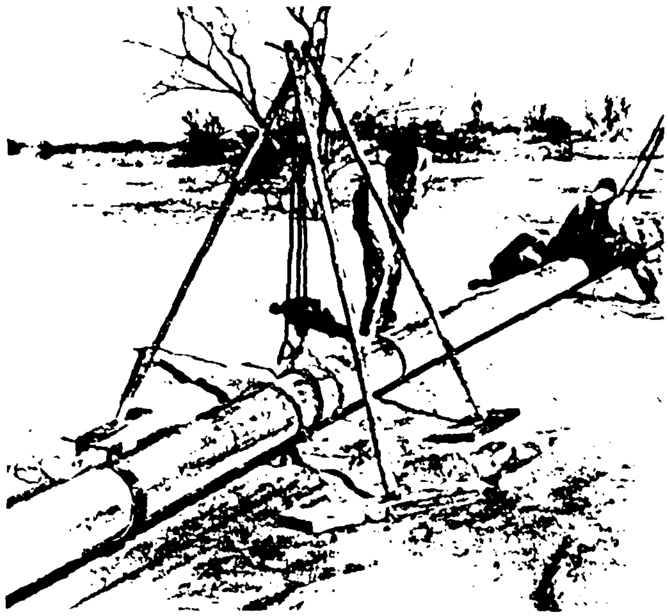


FIG 5—EQUIPMENT AND METHOD USED IN RAISING PIPE LINES FOR DAM BUILDING.

head for any leakage. A pipe line was then laid from the mill and, beginning at the east end of the dam, table tails were pumped (using clear water) to grade against the chat. The line was advanced westward until the entire south dam face was covered. From this stage dam raising was continued to 835 elevation east and 825 elevation west by the method developed by the Federal Mill organization. Approximate quantities of pumped materials are: 13,000 cu yd of table tails and 263,500 cu yd of complete tails.

Most of the equipment used for dam raising at the Federal Division is shown in Fig 5. The tripods are made by bolting three pieces of 2-in. pipe or discarded 10-ft diamond-drill A-rods together with a $\frac{3}{4}$ by 10-in. bolt and inserting a 10-in. The line is raised to full height by progressively lifting with $1\frac{1}{2}$-ton chain hoists, where it is fastened to the clevis with an 8-ft piece of $\frac{3}{8}$-in. chain equipped with a hook on one end.

Half-inch holes are then burned at 8-ft intervals in the pipe bottom and covered with bands made from $\frac{1}{8}$ by 3-in. mild-steel straps, to which are riveted linings ripped from wornout conveyor belting. The use of $\frac{1}{2}$ by 6-in. bolts at the opening in these bands leaves a gap that permits the insertion of two opposing wedges made from 2 by 4-in. oak.

In operation the line is filled with water and feed is put on, then the tailings-disposal man, by loosening wedges, slips the bands from as many holes as can be operated without washing. Holes

FIG 6—GENERAL VIEW OF DAM SPILLWAY AND PUMP HOUSE
Riprapped terraces can be seen on dam forming the pond used for storing mill water supply.

FIG 7—VIEW TAKEN FROM OVERFLOW STRUCTURE.
Pumphouse in foreground, mill in the distance.

near tripods are not usually run until the pipe has been supported by filling at mid-positions. When tailings have filled to the pipe the bands are slipped over the holes and tightened by hammering the wedges.

If filling is desired on only one side of a line a dam is thrown up with a small gasoline crawler-type crane.

When the dam fill reached the required height, the top was shaped into a road bed by a bulldozer and surfaced with minus 2-in. material, both to provide traction and to prevent washing and wind erosion. The steep northern slope was faced with plus 2-in. rock to control washing and blowing.

FIG 8—REINFORCED CONCRETE COMBINATION OVERFLOW STRUCTURE, BRIDGE AND RECOVERY WATER INTAKE

For overflow and water-recovery purposes a ditch 800 ft long, 24 ft wide and, at one point, 30 ft deep was cut through the knoll at the west end of the dam. Some of the spoil was moved with a scraper hoist, borrowed from the mining department, some with a bulldozer, but the greater portion was loaded into trucks by Keystone Skimmer shovels and used for fill above the 800-ft elevation. Ditching, backsloping and the notching for the overflow structure amounted to 14,800 cu yd in the solid.

The overflow structure, which is really a combination bridge, mill-water-supply intake and pond-level-control device, is 45 ft high and required 400 cu yd of heavily reinforced concrete. The plan calls for lifting the bridge floor and filling the hollow central portion with waste rock, after a semipermanent water level is established and the side sections between piers are concreted to the proper height. The bottom of the recovery-water intake

is connected to the pumphouse by 255 ft of culvert made by pouring concrete around 24-in. drain tile.

The pumphouse is also built of reinforced concrete. It is 21 by 25 ft with an 8 by 14-ft bay on the south side for the electrical control panels. The three 200 kva transformers, which step down the power for the two 200-hp, 3500-gpm pumps, are on the roof.

These two pumps are connected to separate 14-in. cast-iron pipe lines. One line discharges through a concrete bulkhead built in the former No. 2 overflow tunnel of the old slime pond, from which water flows by gravity into the mill; the other connects with an existing 14-in line from No. 1 tunnel (1200 ft from the mill), and flow is directed by a butterfly valve, either to the mill or to the old slime pond. The No. 1 line is 1460 ft to the tunnel intersection; the No. 2 line is 100 ft longer.

Summarizing the advantages to the Federal mill:

1. The dam can be considered to be practically without cost because most materials used had to be wasted, and most of the labor involved would have been doing the same type of work elsewhere.

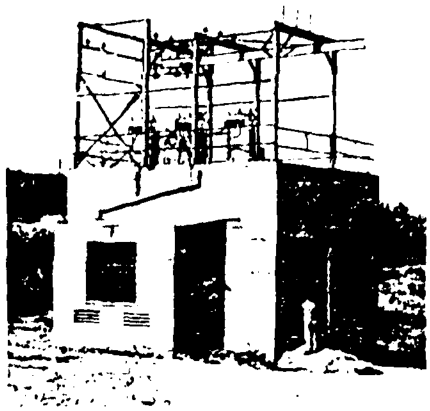


FIG 9—RECOVERY-WATER PUMPHOUSE.
Transformers are 200-kva. The pumps are 3500 gpm driven by 200-hp motors.

2. Ditching, concreting, extra hauling and equipment costs will be offset by power saved in mill-water-supply pumping, which is now being done at reduced heads during periods of lower power demand.

3. The 91½-acre tailing pond has an underwater volume of 73,545,500 cubic feet.

4. Maximum length of tailings-disposal lines is 4800 ft against a static head of 78 feet.

FIG 10—GENERAL VIEW FROM MILL-WATER-SUPPLY DAM.

ST. JOE
MINERALS CORPORATION

P O BOX 500
VIBURNUM, MO 65566
TELEPHONE 314-244-5261

September 6, 1979

Mr. Stan Kline
International Engineering Company
220 Montgomery Street
San Francisco, California 94104

Dear Stan:

When I met Jim Gray on August 28 to inspect the Davis Creek Dam in St. Joe State Park, I came away with a list of questions. He suggested that I send the responses to you since he would probably be on vacation.

1) The two 18" pipes exiting near the spillway have no known functions and could possibly be scrap. As far as is known, they were never used as an overflow device.

2) The low level intake at the decant tower feeds into a 24" line controlled by a valve at the base of the decant tower. The valve is closed, probably to prevent tailings from washing into the valley. This 24" line was the feed to the pump house located in the valley to supply water to the mill pond.

3) The 24" intake line (with flap and gate valve) at the north end of the mill pond was the feed line to the mill. This line was closed when operations ceased.

4) The pump house in the valley had a 24" line entering from the low level intake at the decant tower. There were two 12" lines exiting to pump water up to the mill pond. One line ran to Tower No. 2 outlet tunnel where it fastened to a bulkhead. The other ran to Tower No. 1 outlet tunnel and through the tunnel up to the mill pond. This tunnel was not bulkheaded so the mill pond would have an emergency overflow.

Mr. Stan Kline

5) Outlet size should be the same as the top of Tower No. 1. The pipe was originally connected to the pump house. It is unknown which pipes, if any, were removed during salvage.

6) Tower No. 2 outlet is buried near the intersection of the two dams, exact location unknown. The end is probably still bulkheaded.

7) Three diamond drill holes in the area show the following:

a) Near spillway
- 14' of overburden (all depths are from surface)
- 99' to Davis Shale B.T. dolomite contact
- 468' to B.T. dolomite - Lamotte sand contact

b) Valley Center (near pump house)
- 8' of overburden to B.T. dolomite
- 374' to B.T. - Lamotte contact

c) Near Old Dam
- 38' of overburden
- 42' to top of B.T.
- 412' to top of Lamotte

If I can be of further assistance, please feel free to contact me.

Sincerely,

John E. Kennedy

John E. Kennedy
Director of Environmental Control

SVERDRUP & PARCEL AND ASSOCIATES, Inc.
ENGINEERS-ARCHITECTS
800 N. 12TH BOULEVARD
ST. LOUIS, MISSOURI 63101

January 10, 1977

Team Four, Inc.
14 North Newstead
St. Louis, Missouri 63108

Attention: Mr. Larry Marks

Gentlemen:

Subject: Geotechnical Report
St. Joe State Park

We have examined the tailings dam and the tailings pond in accordance with the contract. Our analysis is based on an examination of aerial photographs and a site visit by Dr. C. C. Chang and G. Richters on December 14, 1976. Special attention was given to the dam, the tailings pond and hydrology during the site reconnaissance.

TAILINGS DAM

Initially, a tailings dam was built in 1906 east of Davis Creek. Then in 1942, a dam was built across Davis Creek. This dam was constructed with coarse gravel and boulders keyed into bedrock and made impervious by filling the voids with the tailings. The Davis Creek Dam was constructed to be impervious to Elevation 792. Crushed rock grading from 2 inches to 28 inches was used for stability and tailings were used to make it impervious as shown on the attached sketch.

Above Elevation 792, the tailings were used to build up the dam and the rock was placed on the tailings face to prevent it from eroding. The tailings were directed to flow upstream of Davis Creek to increase dam thickness. Coarse crushed rock was built up to form a retaining structure for the tailings and water; and subsequently, the tailings were discharged at the headwaters of Davis Creek. In this manner, the coarser tailings consisting of sand-size particles were deposited at the dam to Elevation 830; while above Elevation 830, the fine particles of silt and clay size must have been deposited.

Our observations from field reconnaissance and examination of aerial photographs of the tailings dam across the Davis Creek indicate it to be stable under static conditions; that is, exclusive of seismic conditions. The rock has been placed at a very steep slope of 1-1/4 horizontal to 1 vertical, and local surface sloughing was noted. Because of the loose nature of the rocks on this steep slope, we would strongly recommend that the public be kept off the Davis Creek Dam. On the other hand, the initial tailings dam has stabilized and no surface sloughing has occurred lately.

SPILLWAY

There is a concrete spillway on the west end of the tailings dam. The intake height had been increased as the tailings deposit rose while the ponds were in operation. The structure of this spillway and its outlet control device are all in good condition.

The outlet structure is composed of twin 8 ft by 8 ft concrete conduits and a 30-inch diameter steel pipe with inlet controls. The outflow then proceeds to two 5-ft diameter culverts under a dirt road to be deposited in Shaw Branch. These culverts are in good condition.

There is an emergency spillway resting on top of the bedrock at the extreme west end of the tailings dam. This spillway makes a sharp turn to the east in order that the flow, when this emergency spillway is in use, will join the west fork of Shaw Branch.

The spillway and the emergency spillways are in excellent condition, and no repair work will be necessary. If at some time it would be desirable to discharge water in this area, the erosion problem should be studied.

TAILINGS POND AREA

The tailings, resulting from the lead ore extraction process, were pumped into the tailings pond to settle out. The tailings deposits are similar to natural deposition where the coarse material settles out in faster moving water and finer particles in slow moving water. This was confirmed by our observations that sand-size coarse particles were deposited around the discharge pipes while silt- and clay-size particles were deposited at the extremities near the present lakes and the dam.

The sand-size particles depotied in fast moving water have been deposited in a dense state while the fine particles have

been deposited in a very loose state of near-liquid consistency. Since the mining operations have ceased, a crust due to dessication has formed on the surface of the pond which can support vehicles. However, the crust over the fine grained material is relatively thin (may be as thin as 6 inches) and vehicles have broken through near the lakes. Cracks due to dessication and settlement were noted near the Davis Creek Dam. From the nine hand-auger borings and visual observations, we feel that considerable problems will occur in areas of repetitive vehicle traffic. Any utilities constructed in the low areas in tailings will undergo variable settlement and could introduce undesirable stresses in the utilities.

Our recommendation is to develop areas in coarse sandy areas as outlined on the attached contour drawings. However, for the final design, these areas must be further investigated.

We feel that a small dam can be constructed on the tailings providing the design includes flexibility, self-healing features, and considerable settlement. These considerations would insure the integrity of the dam.

HYDROLOGY

Precipitation

Mean annual precipitation at the project site is about 42 inches. Much of the precipitation comes during the fall, winter, and early spring months. Records for Farmington indicate the average monthly maximum precipitation occurs in May with 4.97 inches and the minimum occurs in December with 2.43 inches.

Snow has been known to fall as early as October, and as late as May. Most of it falls, however, in December, January, and February. The average snowfall is about 10 to 14 inches.

Winter precipitation usually is in the form of rain or snow, or both. Conditions sometimes are on the border between rain and snow; and in these situations, freezing drizzle or freezing rain occurs.

Spring, summer, and early fall precipitation comes largely in the form of showers or thunderstorms. Thunderstorms are most frequent from April to July.

Drainage

The drainage area above the tailings dam is about 6 square miles which in turn is divided into many subdrainage areas for each individual intermittent stream. The runoff over the drainage area is derived from the precipitation and drained through or via the tailings dam into Shaw Branch of Flat River. Precipitation runoff records were not readily available for an immediate analysis; however, we estimated that about 35 percent of annual average precipitation becomes runoff or about 15 inches annual runoff.

The tailings pond is formed from many slurry discharge locations where the slurry was released at various points in time along the ponds. Because the mining operation has been inoperative for quite some time, the tailings pond is essentially free of water. Quite a few lakes were formed at the edges of the tailings ponds.

These lakes are fed by the intermittent streams and possibly by springs. Their bottoms are composed of tailings sediments which make water retention possible. It is anticipated that these lakes grow in size during the wet season and shrink in dry spells. One small lake was observed as not able to retain water on a permanent basis because the bottom is composed of porous rock. This particular lake bottom and others like it may be treated to retain water if preservation of this lake is warranted.

Evaporation - Transpiration

Part of the runoff will be evaporated into the atmosphere or transpired by growing vegetation. The rate of evaporation could be evaluated as part of the lake design. The total rate of evapotranspiration cannot be estimated until a landscape plan is made denoting each type of vegetation to be planted, the quantity of each type, and its transpiration rate. The groundwater table is very close to the surface in the tailings pond. Capillary action will draw moisture through the intergranular pores of the soil to the surface where evaporation will take place. When precipitation is uniformly distributed over a period of time, the moisture is stored in the top layers of soil during the winter and spring months when evaporation and transpiration are low; while during the summer months evaporation and transpiration are higher. This will affect the water level in the lakes.

PRELIMINARY

January 10, 1977

Infiltration and Percolation

Part of the runoff will infiltrate into ground and join the groundwater body which will eventually leave the tailings deposit. To form a lake, the waterflow balance must be achieved. If the percolation from the lake is greater than the replenish water inflow during a period of time, this lake will dry out within that period. Because the tailings dam is permeable, groundwater will be able to seep through to the downstream side to join the natural drainage path.

Very truly yours,

SVERDRUP & PARCEL AND ASSOCIATES, Inc.

James A. Larson
Project Manager

Enclosures

THE DAVIS CREEK DAM

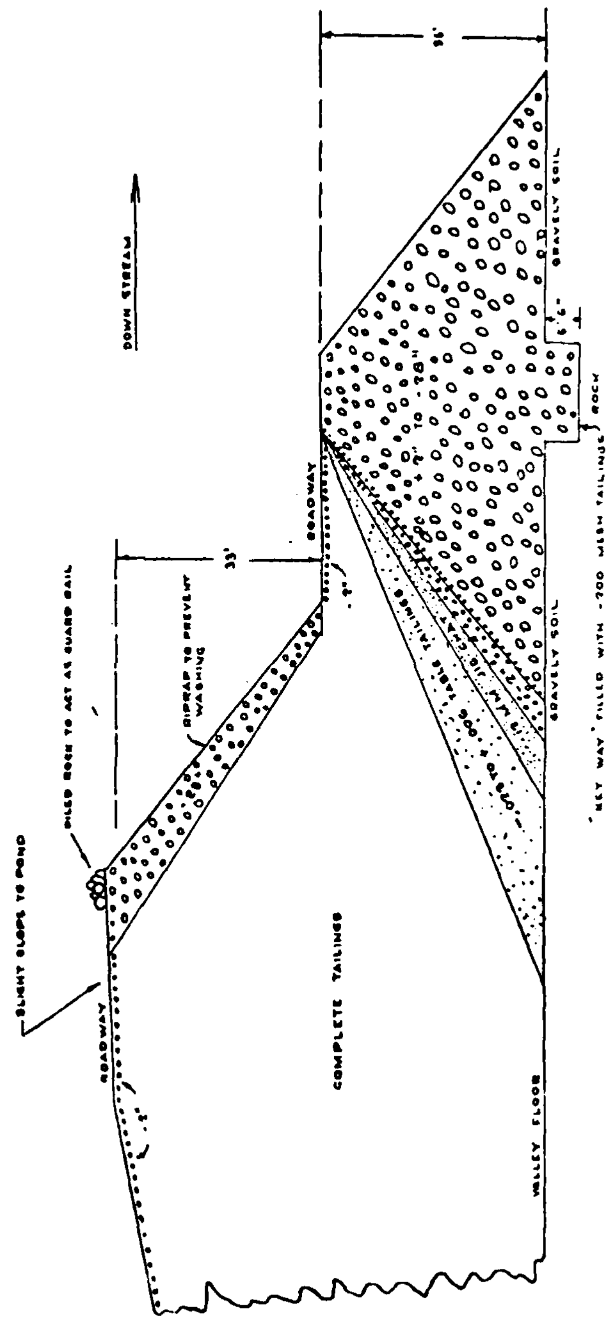


FIG 1—GENERALIZED CROSS SECTION, DAVIS CREEK DAM.

ENGINEERING GEOLOGIC REPORT ON THE ST. JOE STATE PARK TAILINGS DAM AND ENVIRONS

ST. FRANCOIS COUNTY, MISSOURI

LOCATION: Portions of Secs. 16, 17, 18, 20, and 21, T. 36 N., R. 5 E., Flat River and Farmington Quadrangles.

GEOLOGIC SUITABILITY: For lake development, poor.

GEOLOGIC SETTING:

The characteristics of the tailings dam and pond have been outlined in a report furnished by Messrs. Chang and Richters, Sverdrup and Parcell and Assoc. in a letter dated 10 January 1977 addressed to Team Four Inc, of St. Louis, MO. They expressed no concern as to the soundness of the dam but only under static conditions.

The tailings are mainly silt and sand size dolomite particles. A drive tube sample of surface tailings collected near the principal spillway on 9 February 1977 had a permeability of 4.5×10^{-6} cm/sec, or approximately 0.15 inches/day. The unit dry weight was 88.3 pounds cubic foot. Approximately 40% of the sample was fine sand size and 60% silt size. Clay size material was not present. At depths of one foot and greater near the dam, the tailings were wet and soft. A hand auger could be pushed easily. With the possibility that this material is saturated essentially throughout the vertical thickness of the tailings ponds, there is the serious likelihood that the deposits could cause a breach in the upper portion of the tailings dam as a result of sudden acceleration due to a seismic shock. Since the upper portion of the dam is only a veneer of rock over the tailings, the combination of these two features poses the question that a massive failure could occur and affect downstream terrain.

It is unfortunate that the well built starter dam was not continued throughout the construction of the tailings pond. The upstream method of constructing a tailings dam is now considered an unsafe construction technique. This procedure was used after completion of the starter dam. Therefore, it is likely that soft tailings lie directly beneath the crest of the present dam. Verification of conditions near the dam can be answered only by subsurface investigation. Consequently, the initial recommendation is that at least two borings be made either on the crest on the dam or immediately upstream of the dam on the pond surface. The intent would be to verify the character of the tailings, that is texture, the mechanical properties, their density and strength. Obviously, other conditions such as water table, or perched water tables, should be noted. It may well be that the sediments are too soft for sample retrieval. This, of course, would provide one answer as to the strength or absence thereof of the tailings and degree of saturation.

Enlargment of lakes either within the tailings area or at upstream of existing ponds has little chance of success. There appears to be no possibility of constructing a lagoon type facility within the tailings pond area. The water table will fluctuate seasonly, it is likely that the water table gradually is lowering as the water within the tailings pond seeps slowly into the fractured bedrock. In addition there would be extreme difficulty in maintaining side slopes of an excavated lagoon. Disposal of the excavated material would pose still another problem.

The possibility of a successful dam built across the tailings is too remote to consider. A grout curtain or cutoff trench of chemical grout, bentonite or sheet piling would be required. This would have to reach the original valley surface or some 40 to 50 feet deep. Even then one could not assume water loss would not occur into the underlying bedrock on valley slopes. Differential settlement could be designed for but that is additional expense. The tailings are, of course, coarser and more permeable in the upstream lakes area than near the dam. The rate of permeability though has not been determined.

Only one lake in the upstream area appears to have any possibility of enlargement. This lake at elevation 913 feet is located in the NW¼, SE¼, Sec. 20. Here it is suggested that the water level could be raised at least 5 feet. This would require a dam of some 12-15 feet in height with the associated development of an adequate spillway. It may be necessary even here that a total or partial underseepage cutoff will be needed as the water level is raised. Consequently, it is suggested that the exploration drilling program at the main dam also include at least two holes in this area to make some estimate as to the possibility of success in raising lake water level at this location.

Another upstream lake was examined in SE¼, NW¼, Sec. 21. However, there is little likelihood of enlargement success at this location. A cave exists immediately downstream on the left valley slope. This is somewhat unusual for this bedrock formation to have a solution enlarged feature of this magnitude. However, it is of interest to note that only a short distance to the southeast, catastrophic sinkhole collapses have occurred. At least 20 collapses have been recorded in Farmington, all of course in the same bedrock formation as at the St. Joe State Park.

SUMMARY:

From a geologic aspect, there appears to be little possibility of a creation of one or more large water impoundments at the St. Joe Park. One lake located in the NW¼, SE¼, Sec. 20 has some features which would indicate the water line could be raised perhaps 5 feet.

A serious question exists as to the safety of the main dam in the event of an earthquake. Thus, it is urged that exploration be planned both to verify the stability of this dam as well as to consider the possible enlargement of the lake located in Sec. 20. Lastly, it is suggested that if the dam appears to be a risky proposition in the event of an earthquake, one should consider the extent of potential downstream damage. It may well be that a portion of the dam could be breached or dewatered by drains. If that expense is burdensome, the area downstream could perhaps be zoned to prevent occupancy so that if a failure should occur, loss of life or severe property damage would not be a consequence. The sediment type, saturation, and dam characteristics combine to form an extremely sensitive structure relative to possible earthquake damage. An early assessment of this is needed before other plans are formalized.

J. Hadley Williams

Dr. J. Hadley Williams, Chief
Applied Engineering & Urban Geology
Geology & Land Survey
March 1, 1977

orig: Ken Otke
cc: Austin Tao

Willi

Compaction Test Determination Sheet

Soil Sample TAILINGS-AT- SPILLWAY-OUTLET ST-JOE-DAM

Test No. # 13

Date 2/28/77

Tested by [illegible]

Location NE¼-SEC18-36N-5E

Test type [illegible]

Sample No. #-1-ST-JOE-PARK

Mold [illegible]

Specific Gravity

Weight 616.0

$\frac{429.1}{4.541.0}$ 94.5

Density

Run No.	# 13						
Wt. Mold + Soil	616.0						
Wt. Mold lbs.	186.9						
Wt Comp. Soil lbs.	429.1						
Wet Density in lbs./ft³		94.5	—	88.3	PCF.		
Dry Density lbs./ft³ γd		107.0					
Void Ratio e							
Porosity n							

> #200 = 40%

< #200 = 60%

K = 4.5×10⁻⁶ cm/sec (0.15"/day)

Water Content no clay —

Run No.	# 13						
Container No.	N-36						
Cont. + Wet Soil in gms.	90.02						
Wt. Container + Dry Soil gms.	85.03						
Wt Water gms. W_w	4.99						
Wt. Container gms.	14.62						
Wt Dry Soil gms. W_s	70.41						
Water Content W%	07.0						

Percent Saturation

	W	γd		W	γd
S = 100%			S = 80%		

MISSOURI
GEOLOGICAL SURVEY AND WATER RESOURCES

PERMEABILITY TEST

ST. FRANCOIS - CO

PROJECT: ST-JOE DAM - TAILINGS	DATE SAMPLE: FEB 77 BY
LOCATION: NE¼-SEC 18-36N-5E	DATE TESTED: 2/25/77 BY
BORING NO.: SAMPLE NO: II 1	DATE COMPUTED: — BY —
DEPTH: SURF ELEV:	DATE CHECKED: — BY —
PERMEAMETER NO	DATE PLOTTED: — BY —

RUN NO.	WATER TEMP. ^{o}C	SAMPLE LENGTH CM L	INITIAL HEAD CM H_1	FINAL HEAD CM H_2	TEST TIME SEC. t	$LOG_e \frac{H_1}{H_2}$	$\frac{aL}{At}$	K CM/SEC	TEMP. CORR
II 13		6.72	75.5	20.6	93,000		.0000574		
									/

a - STAND PIPE AREA = 1.75 CM^2

A - SAMPLE AREA = 41.94 CM^2

$K = \frac{aL}{At} LOG_e \frac{H_1}{H_2} =$ {PERMEABILITY IN CM/SEC

$e = \frac{SAL - W_s}{W_s} =$ VOID RATIO

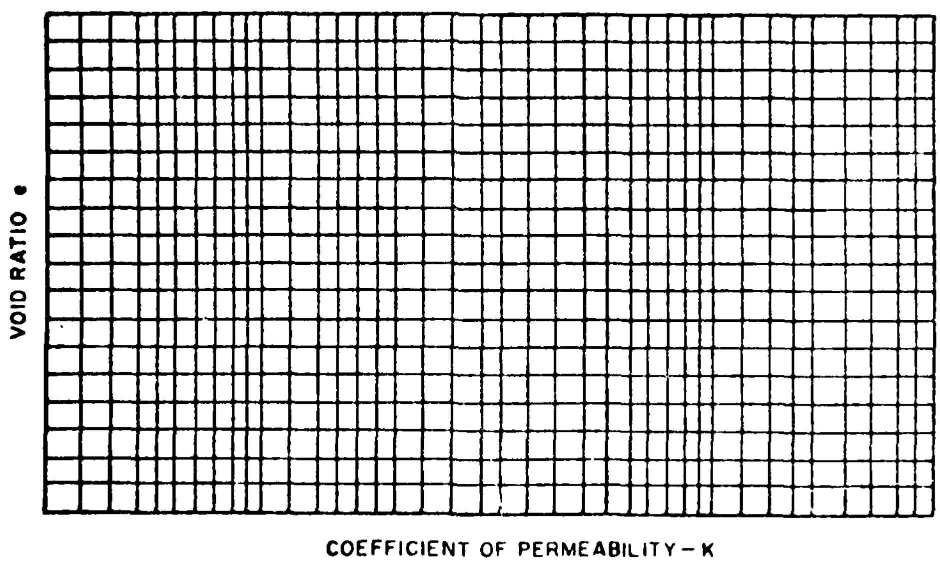
S = SPECIFIC GRAVITY

W_s = WT. OF DRY SOIL IN GMS

= 0.15"/day

SUMMARY

TEST	WT DRY SOIL	e	K $\frac{CM}{SEC}$



TAILINGS DAM INVESTIGATION

ST. JOE STATE PARK
FLAT RIVER, MISSOURI

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

January, 1978

SVERDRUP & PARCEL AND ASSOCIATES, Inc.
St. Louis, Missouri

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TAILINGS DAM INVESTIGATION
ST. JOE STATE PARK
FLAT RIVER, MISSOURI

A. INTRODUCTION

1. Authorization

A study of the subsurface investigation and stability analysis under seismic conditions was authorized by the Department of Natural Resources, State of Missouri. A contract for the project, made on August 9, 1977, was signed by the Department and Sverdrup & Parcel and Associates, Inc. (SPA).

2. Scope of Work

The purpose of this investigation was to study the stability of the tailings dam under seismic conditions. As part of this investigation, borings were drilled and soil samples were obtained and classified to determine the subsurface profiles. Field tests such as vane shear tests, blow counts and permeability tests were conducted to determine the tailings shear strengths, consistency and permeability. Based upon the field investigations and laboratory analyses, slope stability under seismic conditions have been calculated.

B. SITE DESCRIPTION AND SUBSURFACE INVESTIGATION

1. Site Description

The St. Joe tailings dam was built to retain tailings from mining of the lead-ore deposits in the vicinity of Flat River, Missouri. The tailings operation was ceased after 1965, and the property was donated to the State of Missouri as a state park. The area covers about 9,000 acres.

2. <u>Subsurface Investigation</u>

Three borings were drilled to bedrock under the tailings for the subsurface investigation. The location of the borings is shown in Figure 1. The boring report is included in Appendix A.

Vane shear tests were conducted in the borings as they were advanced to determine the in-situ shear strength. The vane shear strength of fine tailings ranges from 600 psf to 1250 psf for initial shear strength and 400 psf to 600 psf for remolded shear strength.

The standard penetration tests were obtained to determine the blow count of the tailings. Based upon the blow counts, the relative densities for the upper 30 ft of the tailings are about 20 percent. These poorly compacted tailings are susceptible to liquefaction and settlement induced by earthquakes. For the lower part of the tailings, densities are in the range of 60 to 80 percent.

Results of the field permeability tests show that the permeability ranges from 4.06×10^{-4} cm/sec to 2.55×10^{-3} cm/sec, which is considered to be low.

The water table was encountered at 1-1/2, 3 and 11 ft below the ground surface in Borings 1, 2 and 3, respectively. Based upon the boring report and permeability analysis, it is believed that currently the tailings dam is saturated.

Tailings samples were brought to the laboratory for grain-size analyses. The results may be seen in Appendix B. The analyses not only confirm the grain-size distribution, but the results can be employed to determine the internal friction angles. The strength parameters, cohesions and internal friction angles will be used for stability analysis.

Based upon the subsurface investigation, we have profiled two cross sections, which are shown in Figures [illegible] and [illegible].

C. SEISMIC ANALYSIS, LIQUEFACTION AND SETTLEMENT

1. Liquefaction

Ground shaking from earthquakes in recent years has often resulted in catastrophic failures in slopes, dams and tailings dams. Under the action of earthquake stresses, deposits of loose, cohesionless, poorly compacted tailings may be densified. However, if drainage is not provided, liquefaction may be induced by progressive buildup of pore water pressure. The tailings in the St. Joe tailings dam are composed of sandy silt, which is susceptible to liquefaction. The computer ground acceleration which will cause the fine silt tailings to liquefy is 0.14g.

2. Settlement

The relative densities of the fine tailings are about [illegible] percent, which is considered to be poorly compacted. Significant settlement may occur due to densification caused by earthquakes shaking. Long-term settlement may occur whether there is a dewatering system or not.

3. Seismic Analysis

The intensity of an earthquake is determined by the amount of damage or felt motion effected by the disturbance. The scale in common use in the United States today is the Modified Mercalli Intensity Scale (MM).

The dam site has undergone considerable seismic activity and does not show nor has any noticeable damage been reported. According to the earthquake map prepared by Kinematics Research, Ltd. (1976), the above site is not expected to experience greater intensity than VII on Modified Mercalli Intensity Scale; there is a 90 percent probability that ground acceleration of 0.1g to 0.[illegible] will not be exceeded within the next 50 years. The relationship between Modified Mercalli Intensity Scale and ground acceleration may be seen in Appendix C. Since 1942, the site has experienced two events of MM VI intensity and eight events of MM V intensity.

D. DAM STABILITY ANALYSIS

1. Dam Stability Against Shear Strength Failure

A computer program developed by SPA, which is based upon the Swedish Circle Method, was employed to determine dam stability. The strength parameters determined for the tailings with adjustments for the water table were used. The potential slip surface was determined by computer and is shown in Figure 4. The factor of safety, which is defined as ratio of allowable shear strength to shear stress, was calculated and is shown in the following table.

Ground Acceleration a_h Percent of Gravitational Acceleration, g	Factor of Safety Against Strength Failure
a_h = 0.0 (static)	1.10 ~ 1.20
a_h = 0.1g	0.95 ~ 1.05
a_h = 0.2g	0.85 ~ 0.95

Safety factors reflect the slight variations of strength parameters used in the computation. On the basis of this analysis, the tailings dam will be safe for earthquakes at scales less than or equal to MM VI.

2. Liquefaction of the Tailings

It has been determined that the fine tailings will be liquefied if the ground acceleration exceeds 0.14g. Three possibilities may occur under earthquake scale of MM VII.

a. $a_h/g < 0.10$ - No severe damage is foreseen.

b. $0.10 < a_h/g < 0.14$ - The dam will fail due to strength insufficiency.

c. $a_h/g > 0.14$ - The fine tailings will be liquefied and the dam subsequently will be severely damaged.

E. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

Based upon tailings classification and grain-size analyses, we have found that the upper layer is about 40-ft thick and consists mainly of silty or fine sand tailings which are susceptible to liquefaction.

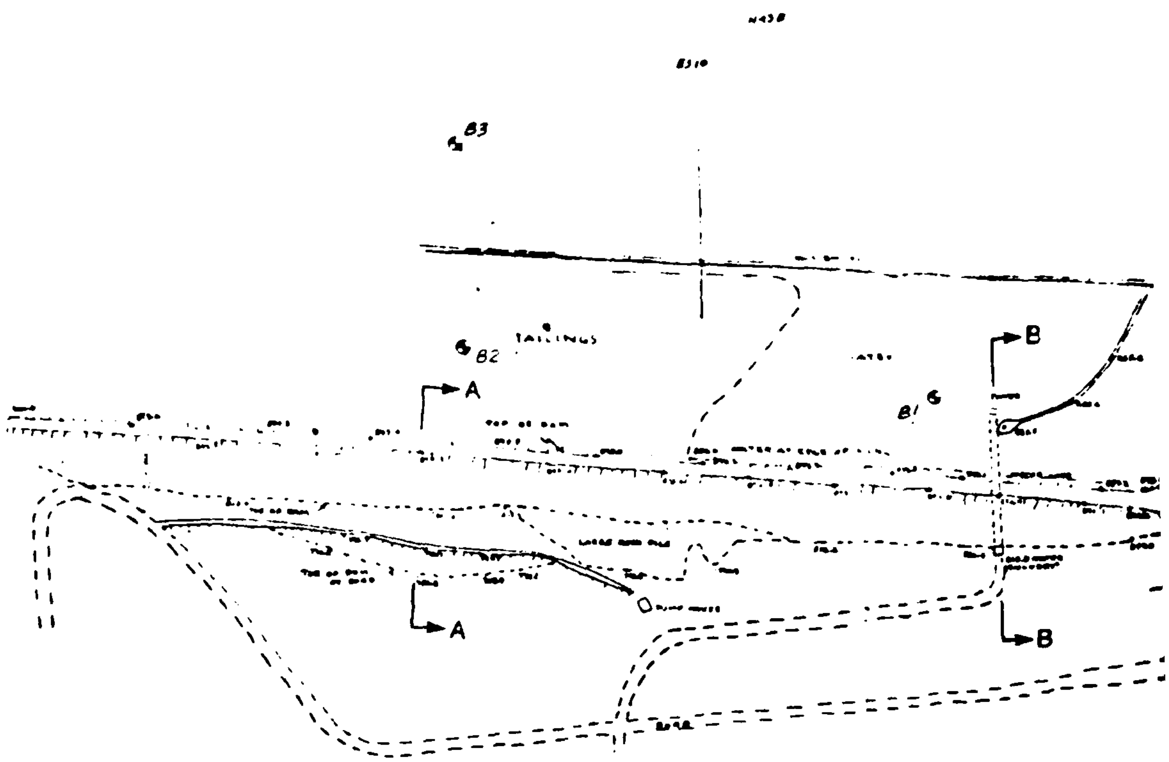
Field permeability tests and analyses indicate that silty tailings have low permeability. The low permeability combined with insufficient dewatering maintains the high groundwater level found in the tailings.

The stability analysis does show that the tailings dam may stand against minor earthquakes (under Modified Mercalli Intensity

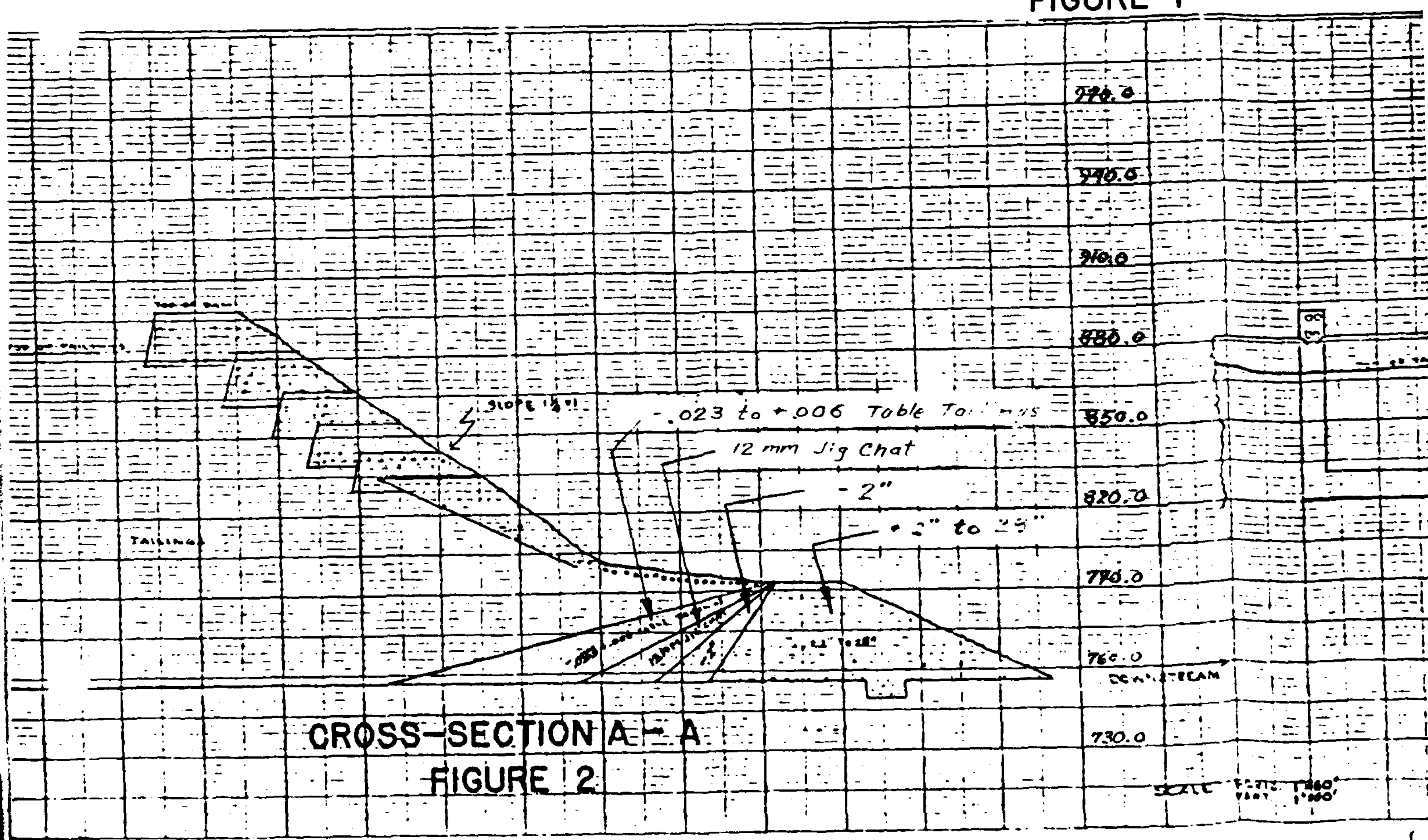
Scale VI). However, failure may be induced if an earthquake of greater intensity occurs and an adequate dewatering system is not provided.

2. Recommendations

To minimize the risk of liquefaction caused by [illegible] stresses, a proper dewatering system should be designed. Since the tailings have low permeability, a long-term dewatering system -- such as a vertical and/or a horizontal drainage system, a mechanical and/or a gravitational drainage system -- should be considered in further investigation.

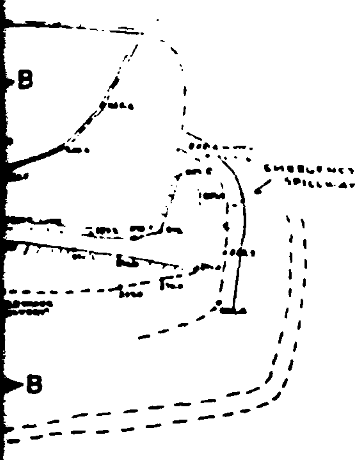


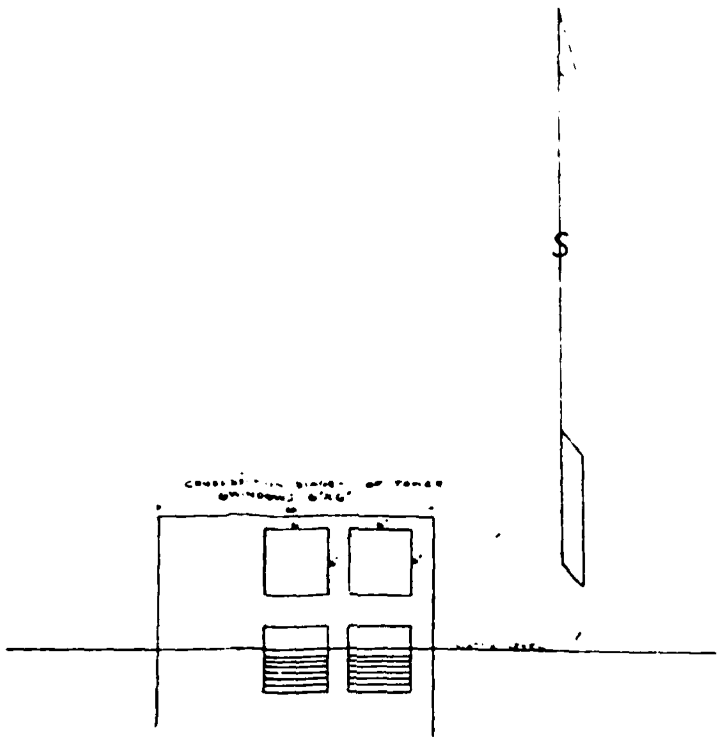
PLAN VIEW OF ST. JOE
TAILING DAM AND BORING LOCATIONS
FIGURE 1



CROSS-SECTION A — A
FIGURE 2

DAVIS CREEK DAM
SCALE 1"=400'





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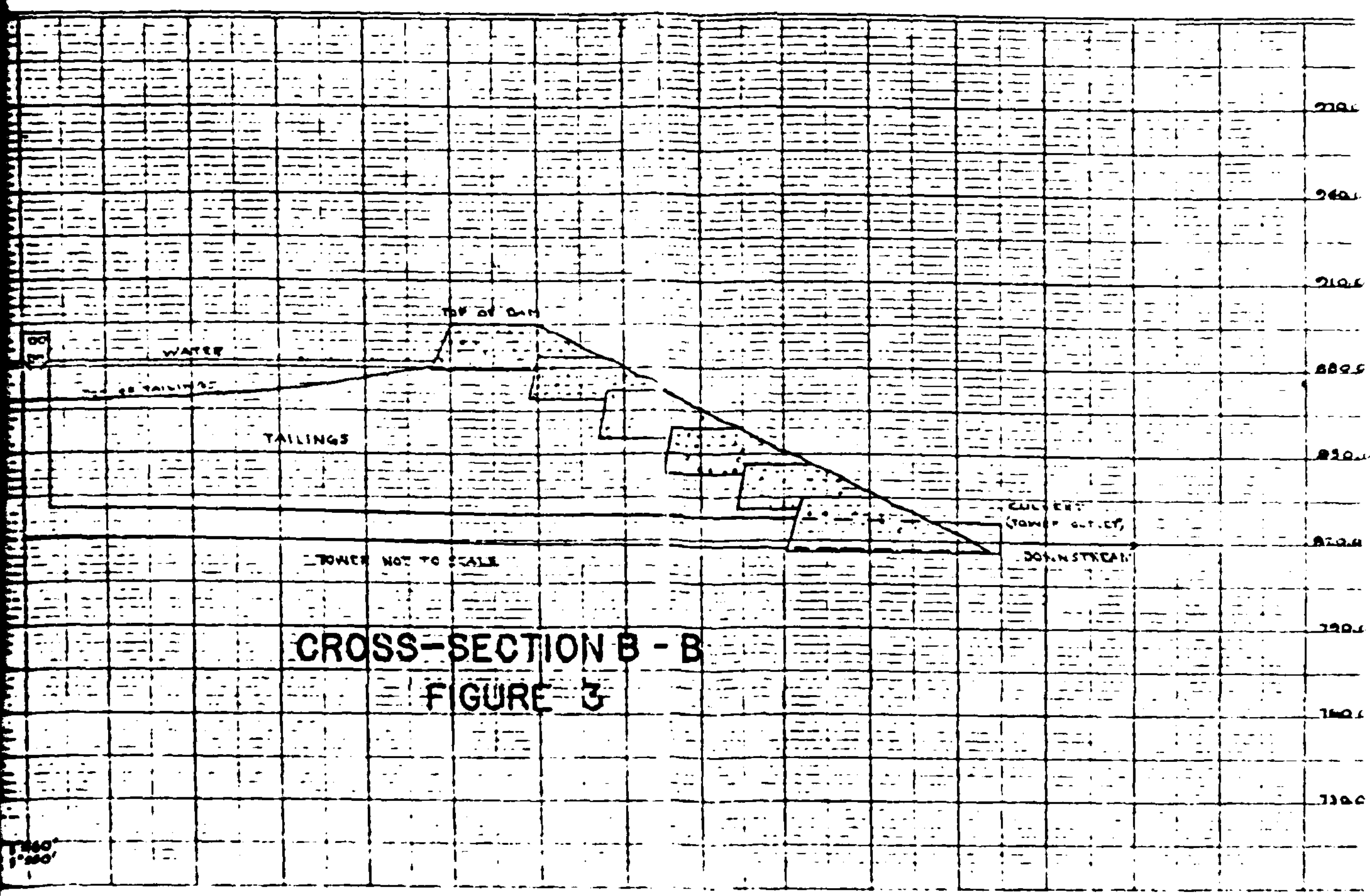
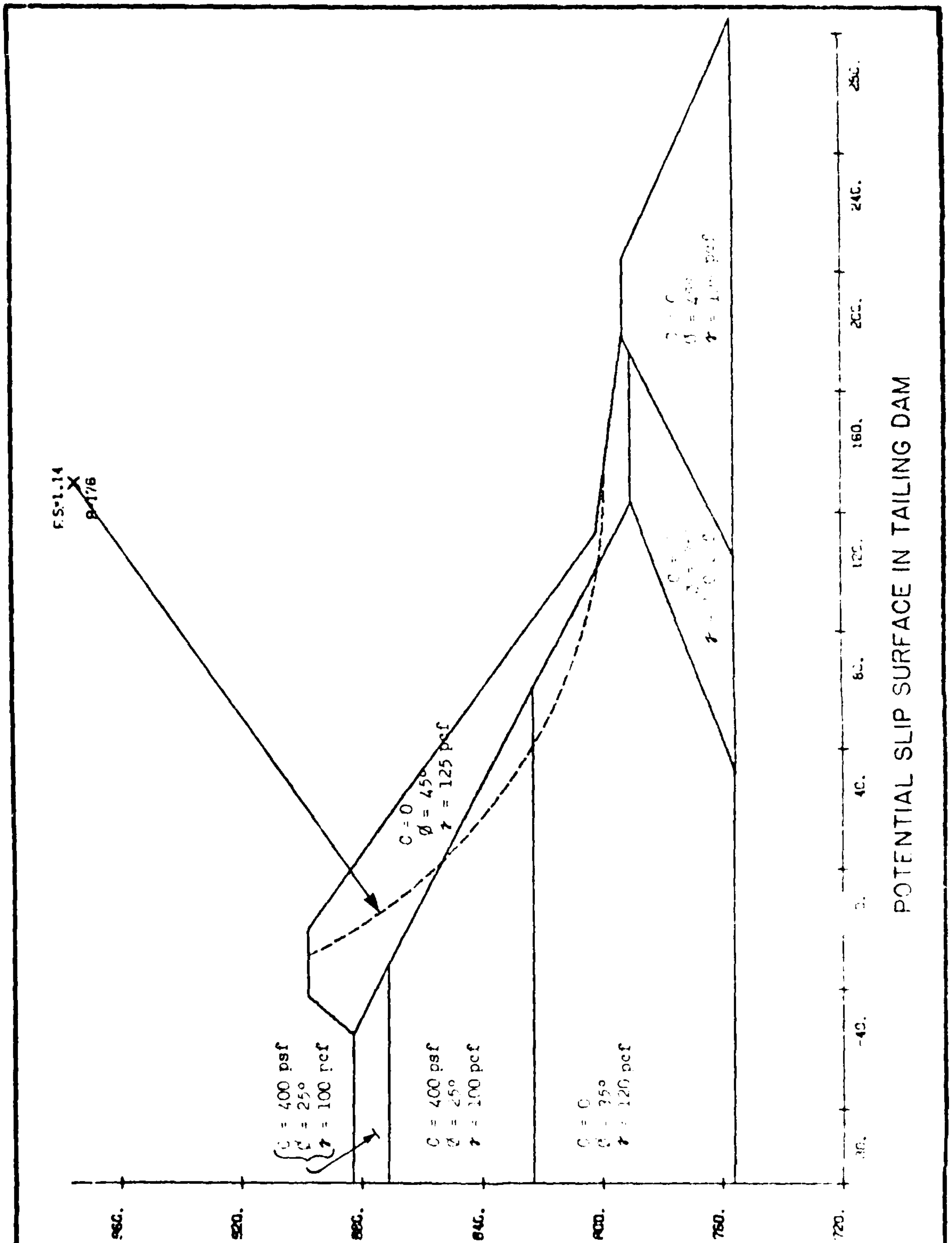


CROSS-SECTION B - B
FIGURE 3



POTENTIAL SLIP SURFACE IN TAILING DAM

FIGURE 4

APPENDIX A

TEST BORING REPORT

RAY 348D

TEST BORING REPORT

RAYMOND INTERNATIONAL INC.

SERVICE CONTRACTS DIVISION

To Sverdrup & Parcel and Associates, Inc. Date December 3, 19 77

Address 800 North Twelfth Boulevard St. Louis, Missouri 63101

WE HAVE COMPLETED THE FOLLOWING BORINGS FOR YOU AT Flat River, Missouri

WITH RESULTS SHOWN BELOW IN ACCORDANCE WITH YOUR INSTRUCTIONS, WE HAVE SENT LABELLED SAMPLES OF THE STRATA ENCOUNTERED.

TO Taken From Job Site ADDRESS

VIA UNDER DATE OF

LOCATION PLAN SCALE 1" =

TEST BORING REPORT

FOR

TAILING DAM, ST. JOSEPH STATE PARK

FLAT RIVER, MISSOURI

Compass Points

This boring report prepared in the St. Louis OFFICE of the SERVICE CONTRACTS DIVISION RAYMOND INTERNATIONAL INC.

By MC

Job No CB-21986-FC

Sheet 1 of 6

RAY 3442 REV 11-71

TEST BORING REPORT

RAYMOND INTERNATIONAL INC.

SERVICE CONTRACTS DIVISION
BORING DEPARTMENT

To Sverdrup & Parcel and Associates, Inc. Date December 6, 19 77 Job No CB-21984-V

Location of Borings Flat River, Missouri Tailing Dam, St. Joseph State Park

All borings are plotted to a scale of 1" = 4 ft using Ground Surface as a fixed datum.

No. 1 No. No.

Ground Surface

Ground Surface 0.0'

1 - 1/20

2/24

Grey Fine Sandy Silt
Or Pulverized Limestone
Fill

1-1-1/21

1 3

1 4

1 1

Weight of rods pushed sampler - No reading

36.0'

Boring Continued Next Column

36.0'

Shear Vane Test 40.8' 150 15

Shear Vane Tests 42' 120 15

Shear Vane Tests 43.3' 130 (56

1 2 3

48.0'

7 18 20

Grey Fine Silty Sand
(Fill?)

1 4 8

7 10'

Dark Grey & Brown
Organic Silty Clay Tr
Fine Sand

62.5'

Bed Rock

65.0

Boring advanced by auger.

FIGURES IN RIGHT HAND COLUMN SHOWN AS FRACTIONS

Numberator -- Number of Blows
Denominator - Penetration (IN INCHES)

Classifications are made from visual inspection of samples and are our opinion thereof.
Water Levels (WL) Figure indicates time of reading (hours) after completion of boring. Water levels indicated are those observed when borings were made. Porosity of the soil strata, variations of rainfall, site topography, etc. may cause changes in these levels.
Figures in right hand column indicate blows required to drive 2" O.D. sampling pipe 6" using 140 lb. hammer falling 30 inches.

Total Footage 65.0'
Foreman
Classifications
Job No. CB-21984-SC
Sheet 2 of 6

RAY 344 2 REV 11 73

TEST BORING REPORT

RAYMOND INTERNATIONAL INC.

SERVICE CONTRACTS DIVISION
BORING DEPARTMENT

To Sverdrup & Parcel and Associates, Inc. Date December 7, 19 77 Job No

Location of Borings Flat River, Missouri Tailing Dam, St. Joseph State Park

All borings are plotted to a scale of 1" = 4 ft using Ground Surface as a fixed datum

No. Ground Surface | No 2 | No

Ground Surface 0.0'

Pulverized Limestone Fill

1-1-1/24

1-1/18

1-1/24

1-1/24

1 1 1

1 1 2

1 1 2

36.0'

Continued Next Column

Grey Fine To Medium Sandy Silt Or Pulverized Limestone (Fill)

1 2 3

2 2

1 2

1 3

13 21 20

13 16 15

Continued Next Page

* - Shear Vane Tests

40.9' 300 - 150

41.5' 170 - 100

42.2'

Classifications are made from visual inspection of samples and are our opinion thereof.

Water Levels (WL) Figure indicates time of reading (hours) after completion of boring. Water levels indicated are those observed when borings were made or at noted. Porosity of the soil strata, ... of rainfall, site topography, etc., may cause changes in these levels.

Figures in right hand column indicate ... blows required to drive 2" O.D. sampling pipe 6" ... falling 30 inches

Classifications by

Job No.

Sheet 3

RAY 344-2 REV 11/73

TEST BORING REPORT

RAYMOND INTERNATIONAL INC.

SERVICE CONTRACTS DIVISION

BORING DEPARTMENT

To: Sverdrup & Parcel and Associates, Inc. Date December 7, 1977 Job No CB-2195-K

Location of Borings Flat River, Missouri Tailing Dam, St. Joseph State Park

All borings are plotted to a scale of 1" = 4 ft. using Ground Surface as a fixed datum

No. 2 (continued)

		72.0'
Grey Fine To Medium Sandy Silt Or Pulverized Limestone Fill	10 16 14	
	9 15 16	
	11 16 21	
	13 15 25	
	19 20 24	
	21 22 19	
	18 21 17	
		108.0'
Bed Rock		110.5'

Boring Advanced By Auger

Classifications are made from visual inspection of samples and are our opinion thereof.

Water Levels (WL) Figure indicates time of reading (hours) after completion of boring. Water levels indicated are those observed when borings were made, or as noted. Porosity of the soil strata, variations of rainfall, site topography, etc., may cause changes in these levels.

Figures in right hand column [illegible] number of blows required to drive 2" O.D. sampling pipe [illegible] using a 140 lb. weight falling 30 inches

Total Footage 38.5'

Foreman W. [illegible]

Classifications by [illegible]

Job No. CB-2195-K

Sheet 4 [illegible]

TEST BORING REPORT

RAYMOND INTERNATIONAL INC.

SERVICE CONTRACTS DIVISION

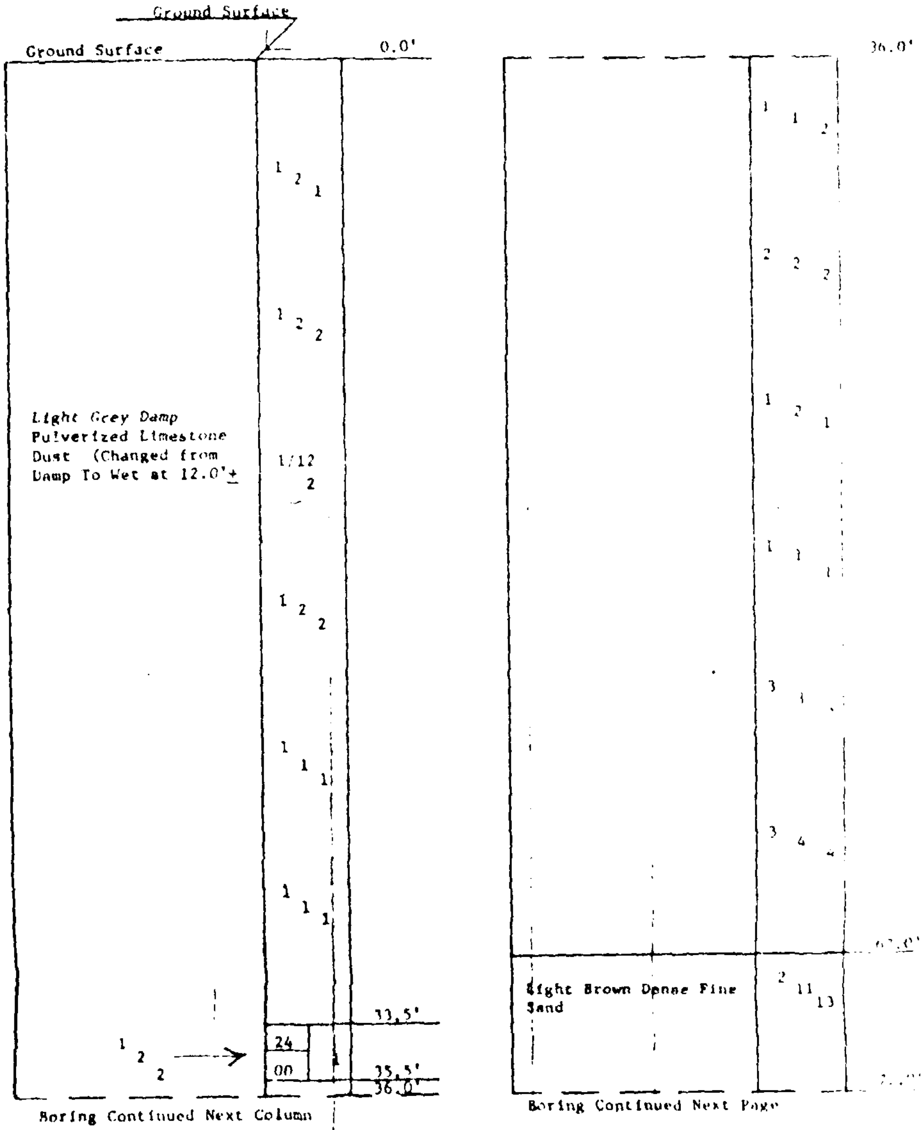
BORING DEPARTMENT

To Sverdrup & Parcel and Associates, Inc. Date December 8, 19 77 Job No

Location of Borings Flat River, Missouri Tailing Dam, St. Joseph State Park

All borings are plotted to a scale of 1" = 4 ft using Ground Surface as a fixed datum

No. 3



Classifications are made from visual inspection of samples and are our opinion thereof.
Water Levels (WL): Figure indicates time of reading (hours) after completion of boring. Water levels indicated are those observed when borings were made or as noted. Porosity of the soil strata, variations of rainfall, site topography, etc., may cause changes in these levels.
Figures in right hand column indicate number of blows required to drive 2" O.D. sampling pipe ... using ... falling 30 inches.

Total Footage

A. House Foreman

Classifications by

Job No. CB-2108

Sheet 5 of 6

RAY 1442 REV 11/75

TEST BORING REPORT

RAYMOND INTERNATIONAL INC.

SERVICE CONTRACTS DIVISION
BORING DEPARTMENT

To Sverdrup & Parcel and Associates, Inc. Date December 8, 1977 Job No. C8-21984-K

Location of Borings Flat River, Missouri Tailing Dam, St. Joseph State Park

All borings are plotted to a scale of 1" = 4 ft using Ground Surface as a fixed datum

No. ______ No. 3 (Continued) No. ______

		72.0'
	8 11 13	
		77.0'
Light Grey Pulverized WET Limestone Dust	3 1 7 6 8 8 13 23 24	
		92.0'
Grey Fine Sand Trace Silt	14 21 20	
		97.0'
Grey Medium Sandy Silt (Maybe Weathered Limestone)	17 18 22	
		102.0'
Bed Rock		
		106.0'

Boring Advanced by Auger

Figures In Right Hand Column Shown As Fractions

Numerator - Number Of Blows
Denominator - Penetration (IN INCHES)

INDICATES SHELBY TUBE

A	C
B	

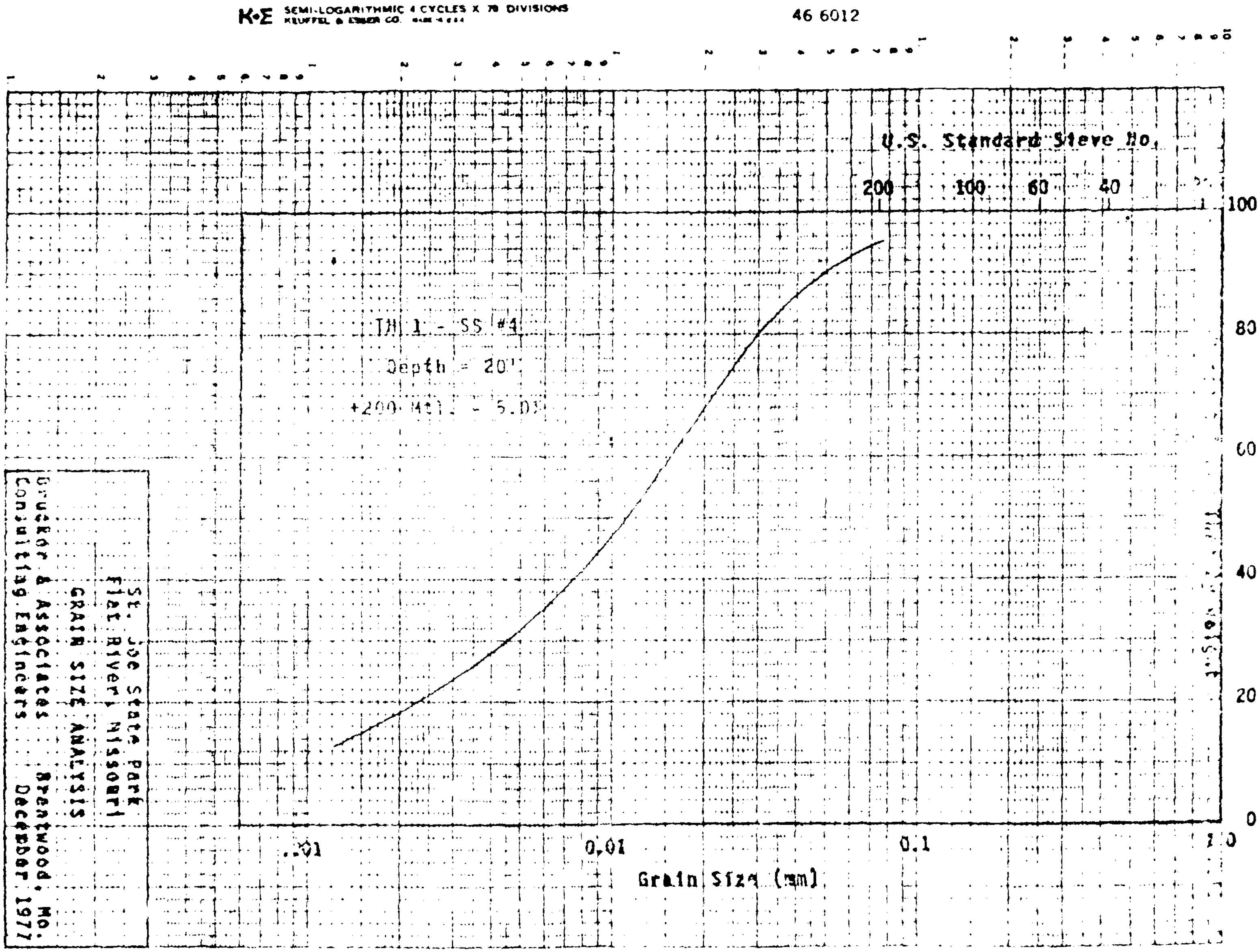
A - Amount of Penetration (IN INCHES)
B - Amount Recovered (IN INCHES)
C - Shelby Tube Number

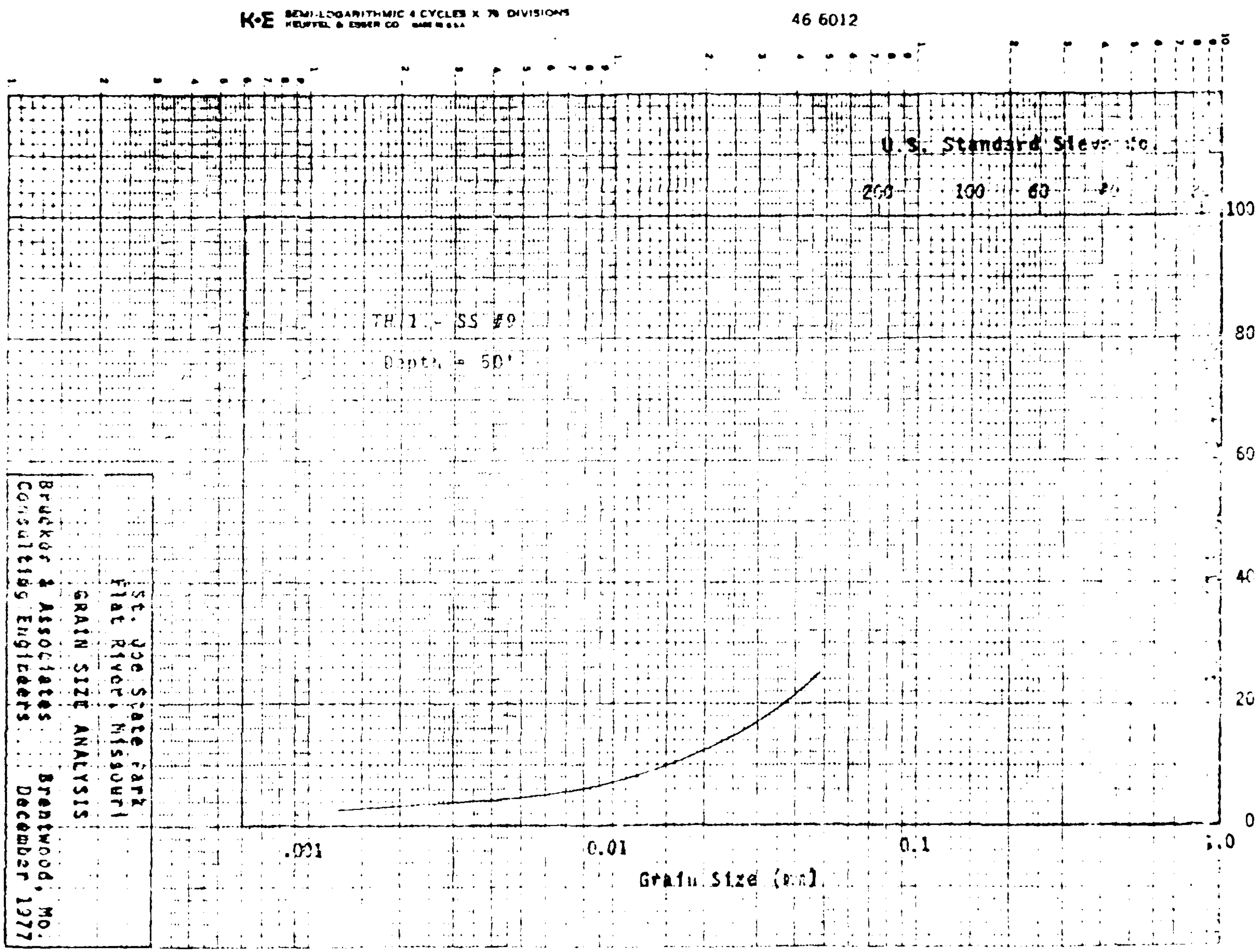
Classifications are made from visual inspection of samples and are our opinion thereof
Water Levels (WL). Figure indicates time of reading (hours) after completion of boring
Water levels indicated are those observed when borings were made, or as noted
Porosity of the soil strata, variations of rainfall, site topography, etc., may cause changes in these levels
Figures in right hand column indicate number of blows required to drive 2" O.D. sampling pipe ... using a 140 ... falling 12 inches

Total Footage 34.0'
Foreman A. Houme
Classification by
Job No. C8-21984-K
Sheet 6 of 6

APPENDIX B

GRAIN-SIZE ANALYSIS

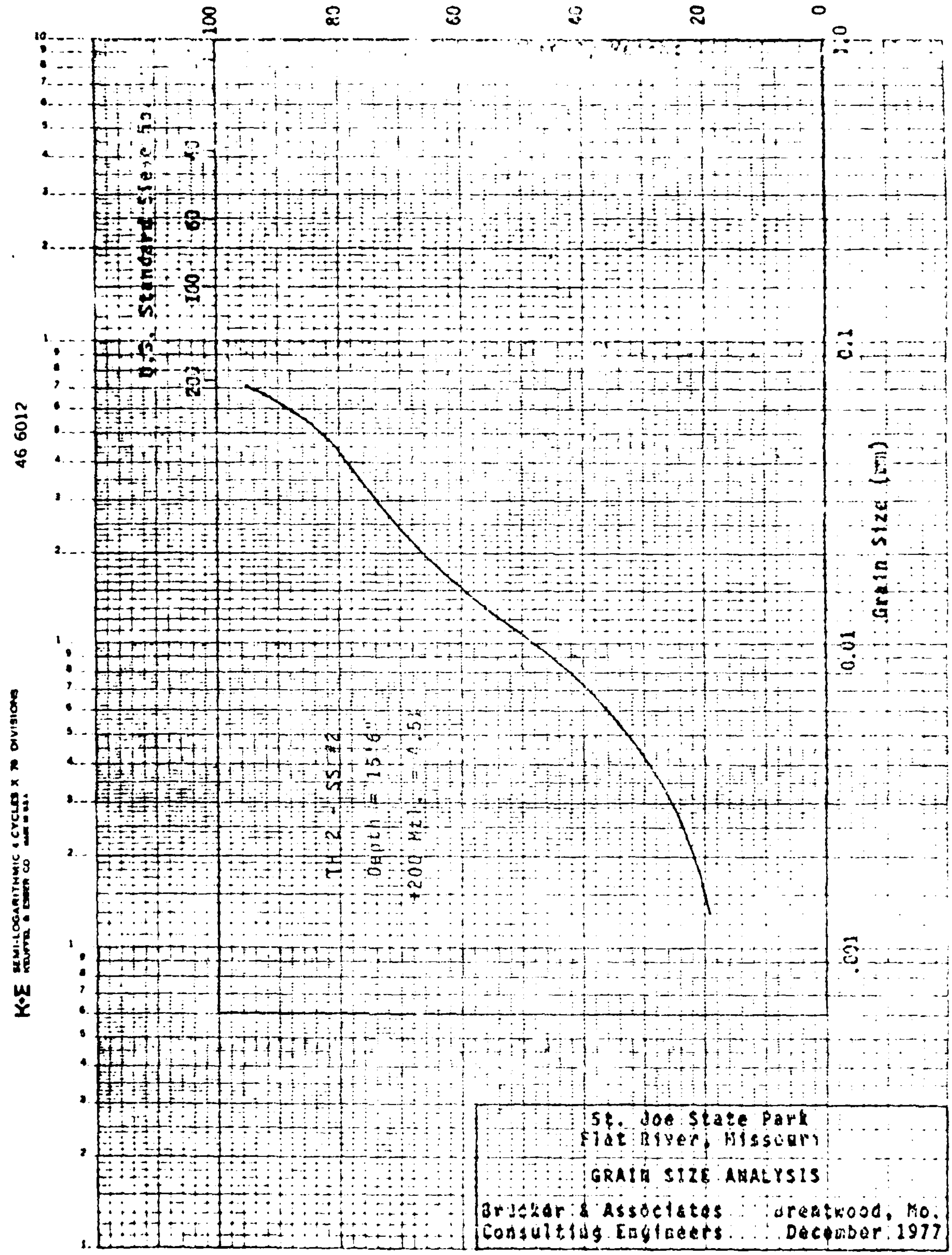

K·E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.
46 6012
U.S. Standard Sieve No.
200
100
60
40
100
80
60
40
20
0
TH 1 - SS #4
Depth = 20'
.001
0.01
0.1
1.0
Grain Size (mm)
St. Joe State Park
Flat River, Missouri
GRAIN SIZE ANALYSIS
Brucker & Associates
Brentwood, Mo.
Consulting Engineers
December 1977



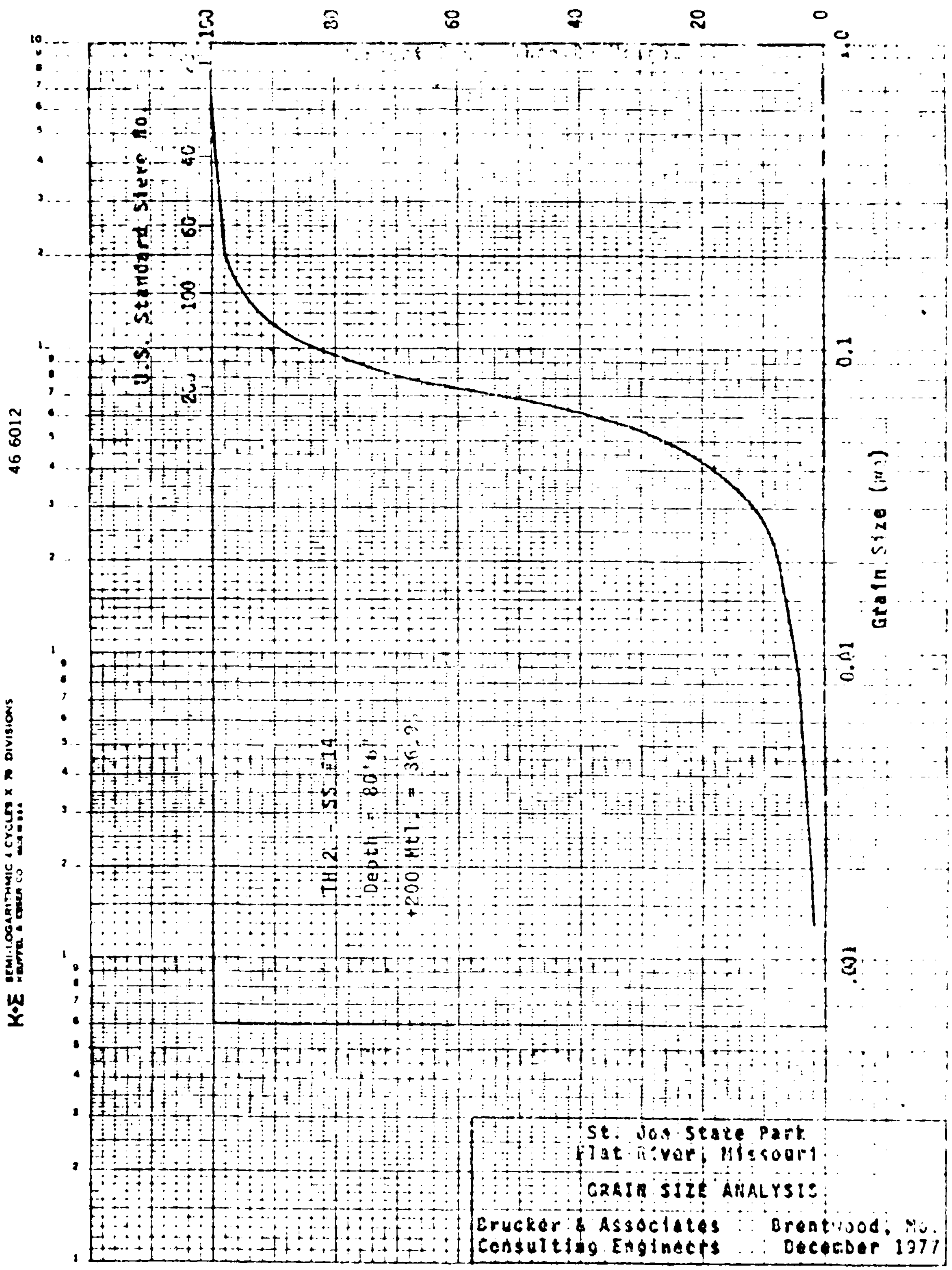
St. Joe State Park
Flat River, Missouri

GRAIN SIZE ANALYSIS

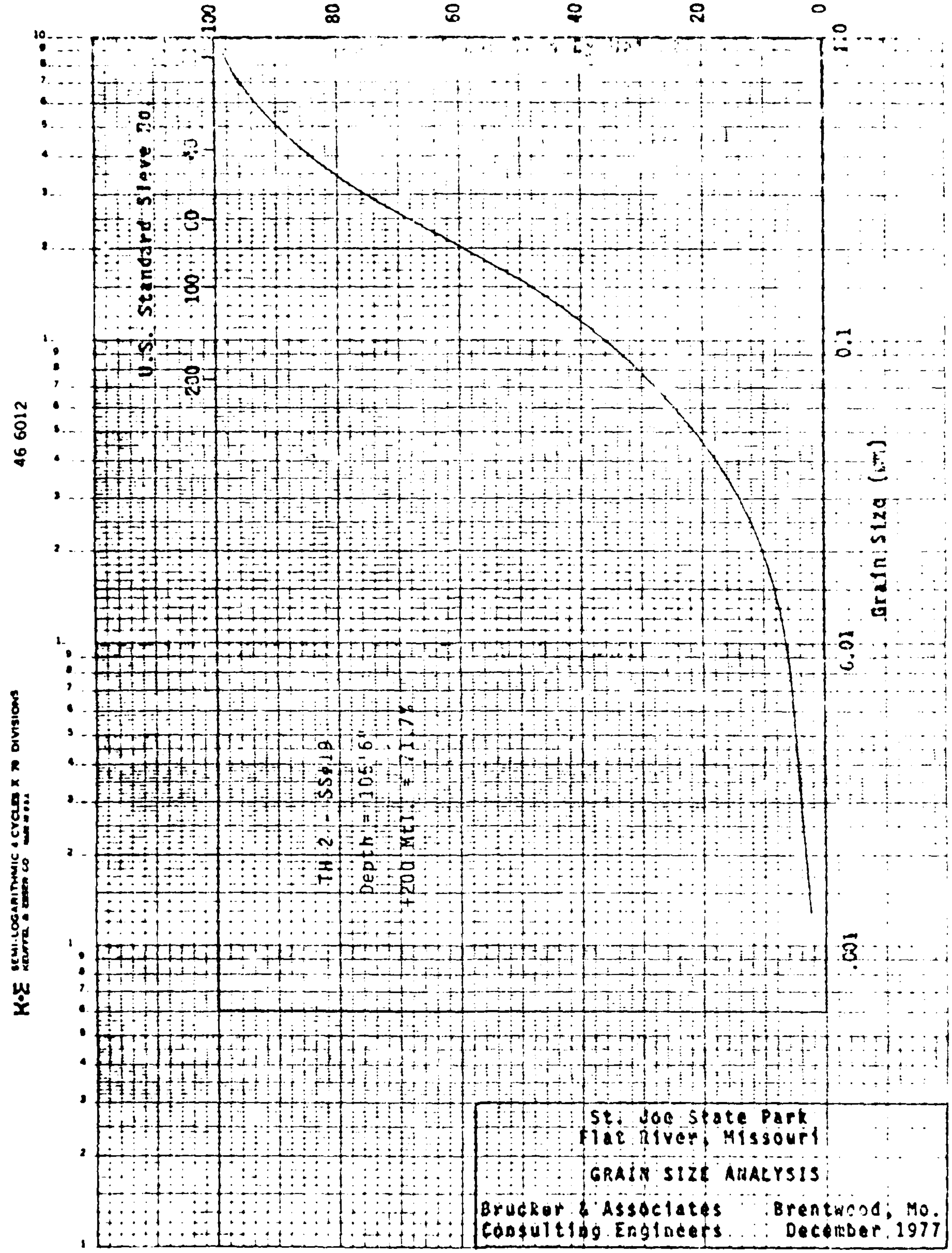
Bruckor & Associates . . . Brentwood, Mo.
Consulting Engineers . . . December 1977



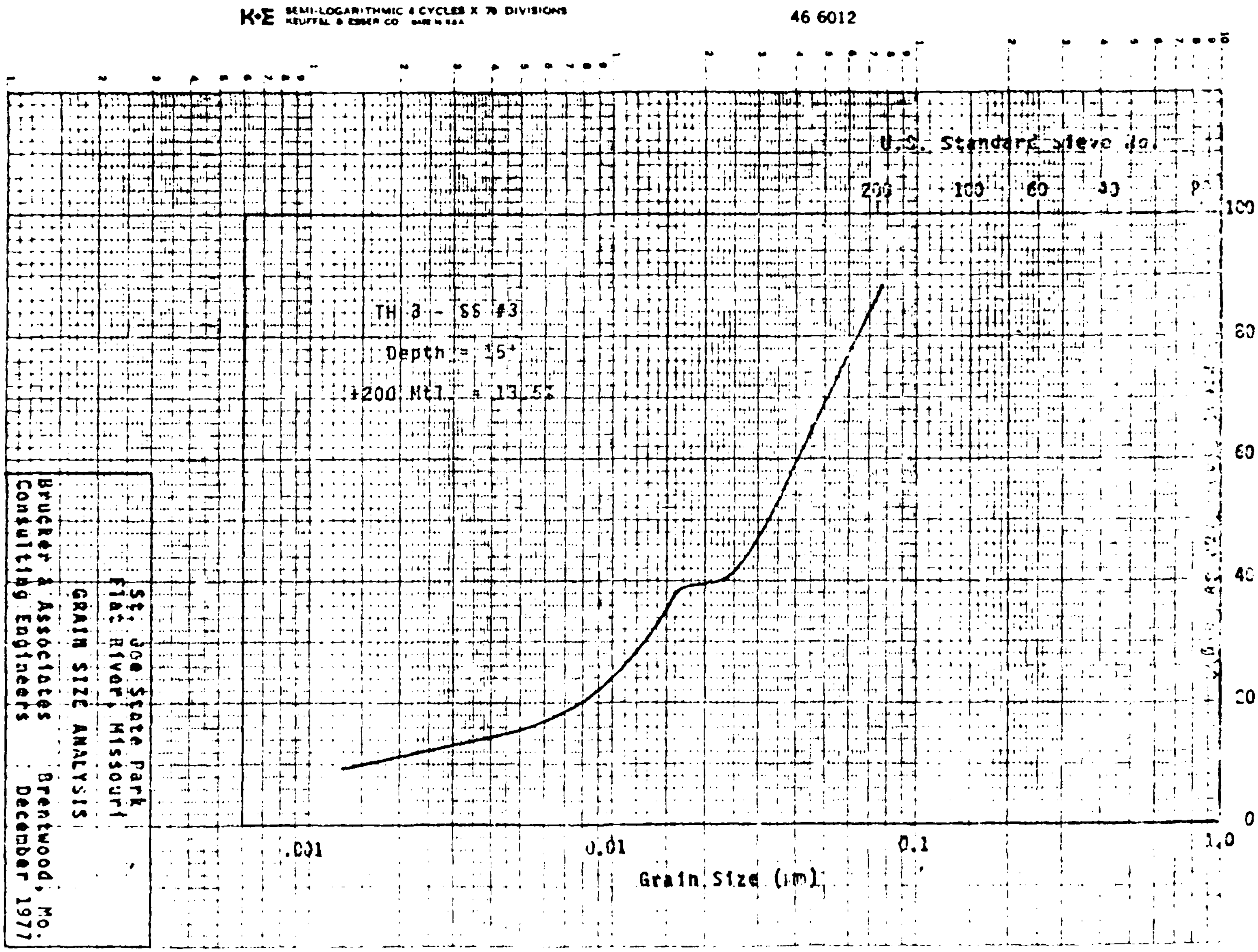
46 6012
K•E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
U.S. Standard Sieve No.
40
60
100
200
100
80
60
40
20
0
1.0
0.1
0.01
.001
Grain Size (mm)
TH 2 - SS #2
Depth = 15'6"
+200 Mtl. = 4.5%
St. Joe State Park
Flat River, Missouri
GRAIN SIZE ANALYSIS
Brucker & Associates
Brentwood, Mo.
Consulting Engineers
December 1977



K+E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
46 6012
U.S. Standard Sieve No.
40
60
100
200
100
80
60
40
20
0
1.0
0.1
0.01
.001
Grain Size (mm)
TH 2 - SS #14
Depth = 80'6"
+200 Mtl. = 36.2
St. Joe State Park
Flat River, Missouri
GRAIN SIZE ANALYSIS
Brucker & Associates
Consulting Engineers
Brentwood, Mo.
December 1977



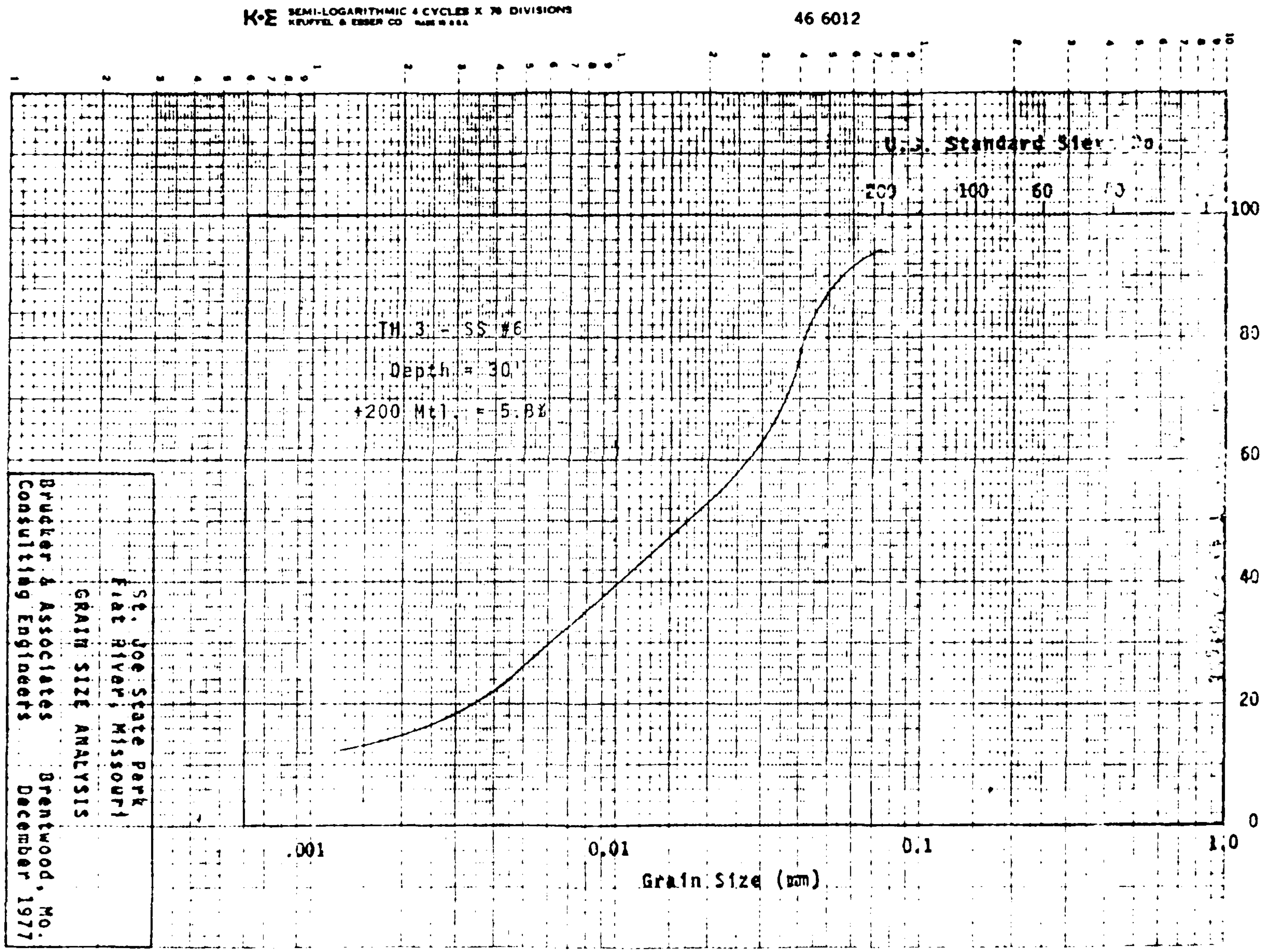
K•E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.
46 6012
100
80
60
40
20
0
U.S. Standard Sieve No.
40
60
100
200
1.0
0.1
0.01
.001
Grain Size (mm)
TH 2 - SS#19
Depth = 105'6"
+200 Mat. = 71.7%
St. Joe State Park
Flat River, Missouri
GRAIN SIZE ANALYSIS
Brucker & Associates
Consulting Engineers
Brentwood, Mo.
December 1977

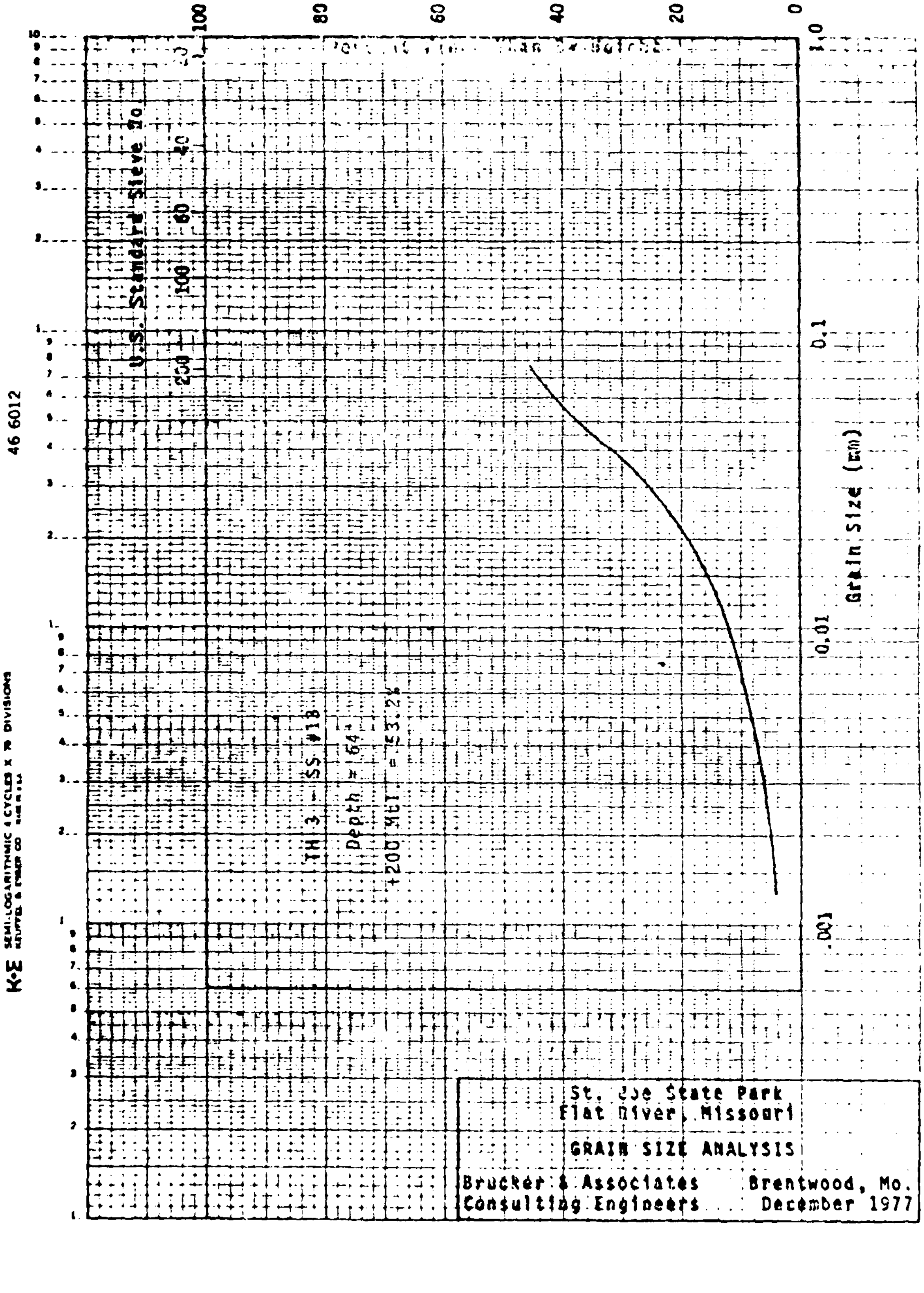


St. Joe State Park
Flat River, Missouri

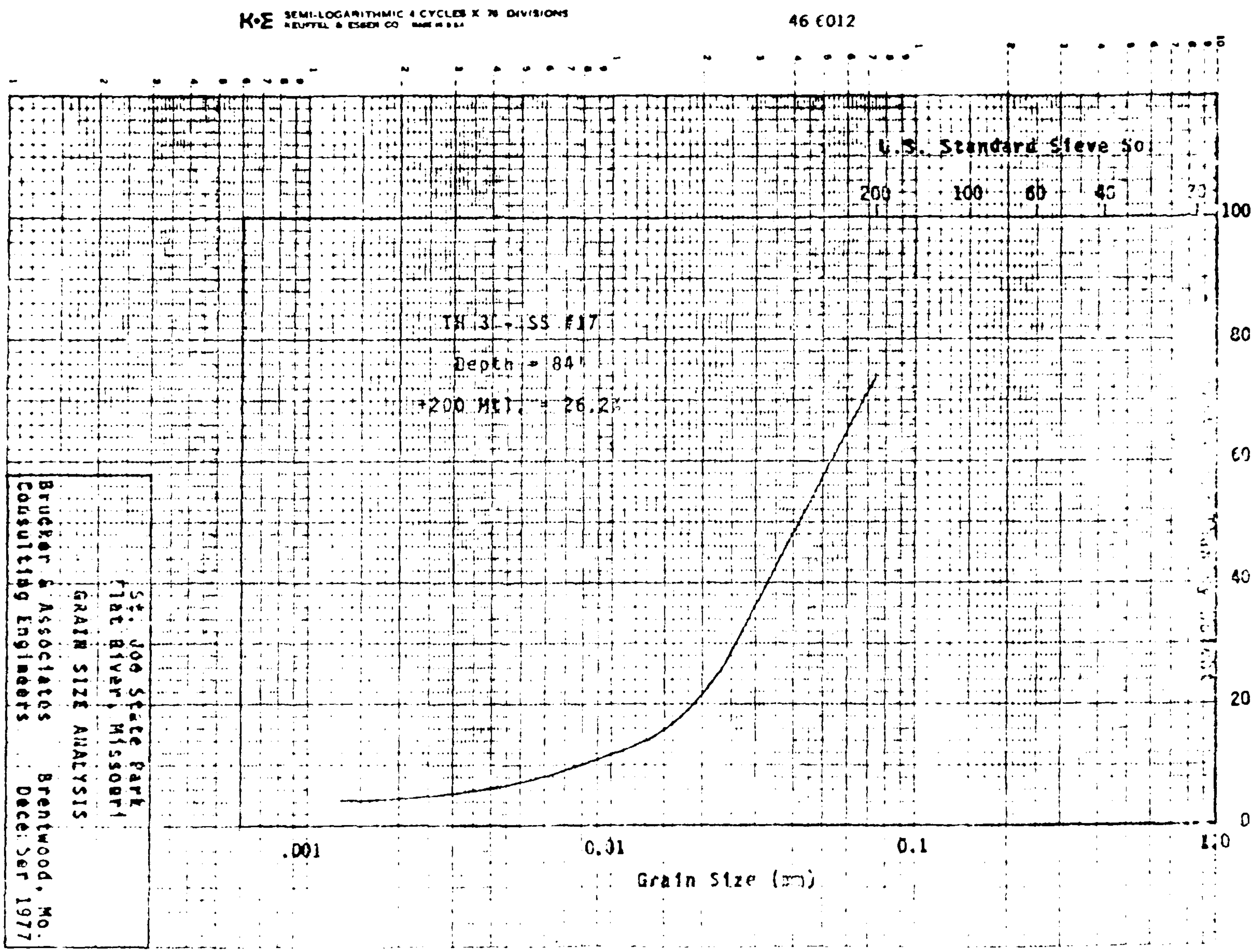
GRAIN SIZE ANALYSIS

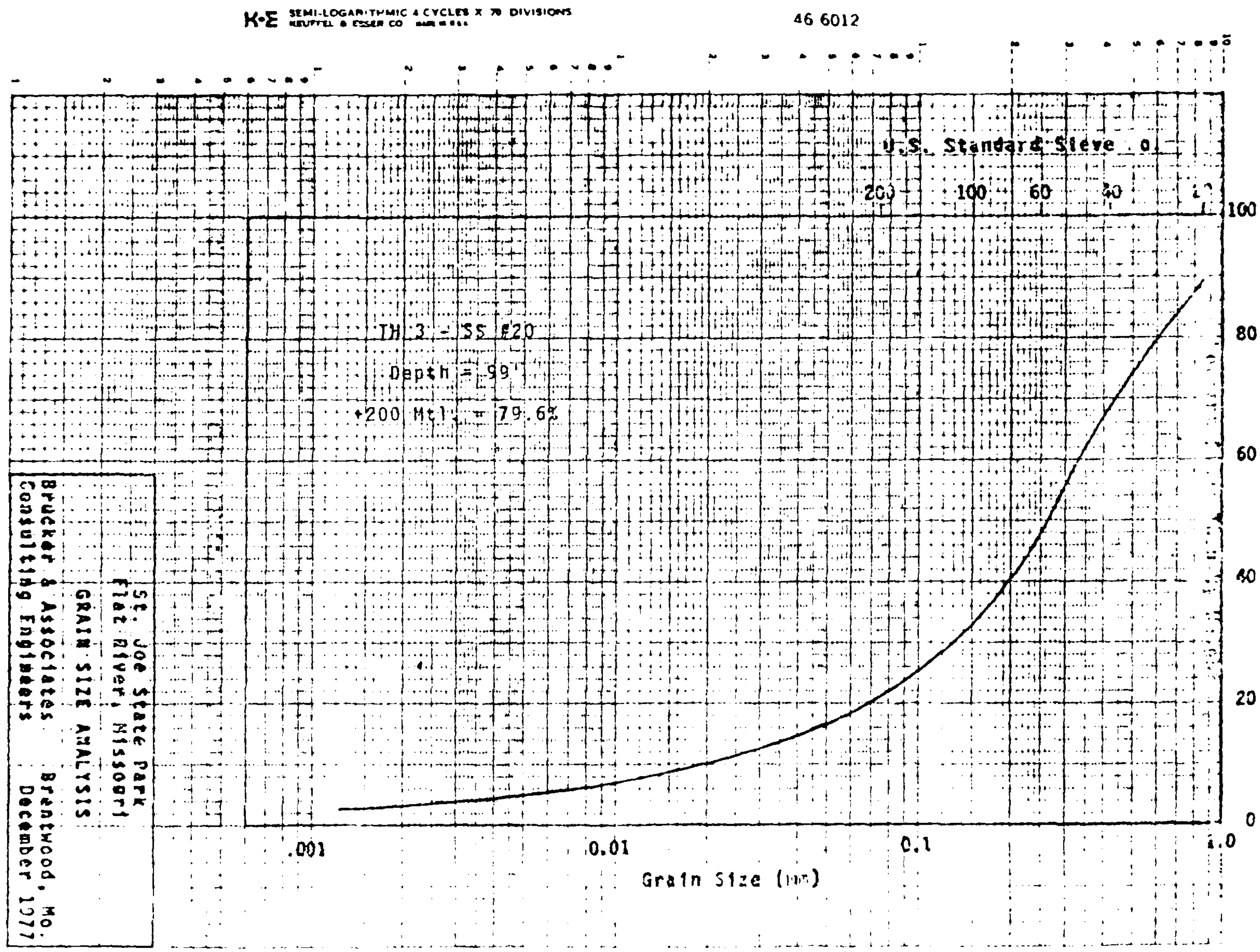
Brucker & Associates Brentwood, Mo.
Consulting Engineers December 1977


K+E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.
46 6012
U.S. Standard Sieve No.
200
100
60
100
80
60
40
20
0
TH 3 - SS #6
Depth = 30'
+200 Mtl. = 5.8%
.001
0.01
0.1
1.0
Grain Size (mm)
St. Joe State Park
Flat River, Missouri
GRAIN SIZE ANALYSIS
Brucker & Associates
Consulting Engineers
Brentwood, Mo.
December 1977



46 6012
K-E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
100
80
60
40
20
0
U.S. Standard Sieve No.
20
40
60
100
200
1.0
0.1
0.01
.001
Grain Size (mm)
TH 3 - SS #18
Depth = 64'
St. Joe State Park
Flat River, Missouri
GRAIN SIZE ANALYSIS
Brucker & Associates
Consulting Engineers
Brentwood, Mo.
December 1977


K·E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO.
46 6012
U.S. Standard Sieve No.
200
100
60
40
100
80
60
40
20
0
TH 31 - SS #17
Depth = 84'
+200 Mtl. = 26.2%
.001
0.01
0.1
1.0
Grain Size (mm)
St. Joe State Park
Flat River, Missouri
GRAIN SIZE ANALYSIS
Brucker & Associates
Consulting Engineers
Brentwood, Mo.
December 1977



St. Joe State Park
Flat River, Missouri

GRAIN SIZE ANALYSIS

Brucker & Associates   Brentwood, Mo.
Consulting Engineers   December 1977

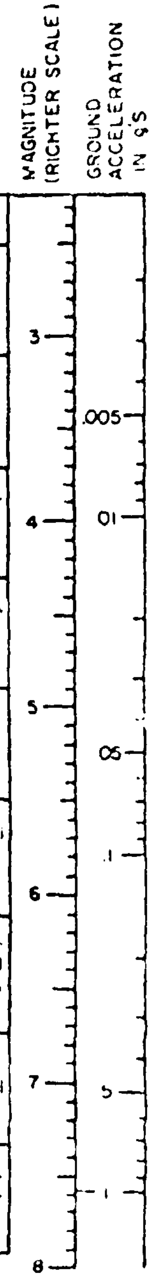
APPENDIX C

MODIFIED MERCALLI INTENSITY SCALE
APPROXIMATE RELATIONSHIP WITH
MAGNITUDE AND GROUND ACCELERATION

MODIFIED MERCALLI INTENSITY SCALE
APPROXIMATE RELATIONSHIP WITH
MAGNITUDE AND GROUND ACCELERATION

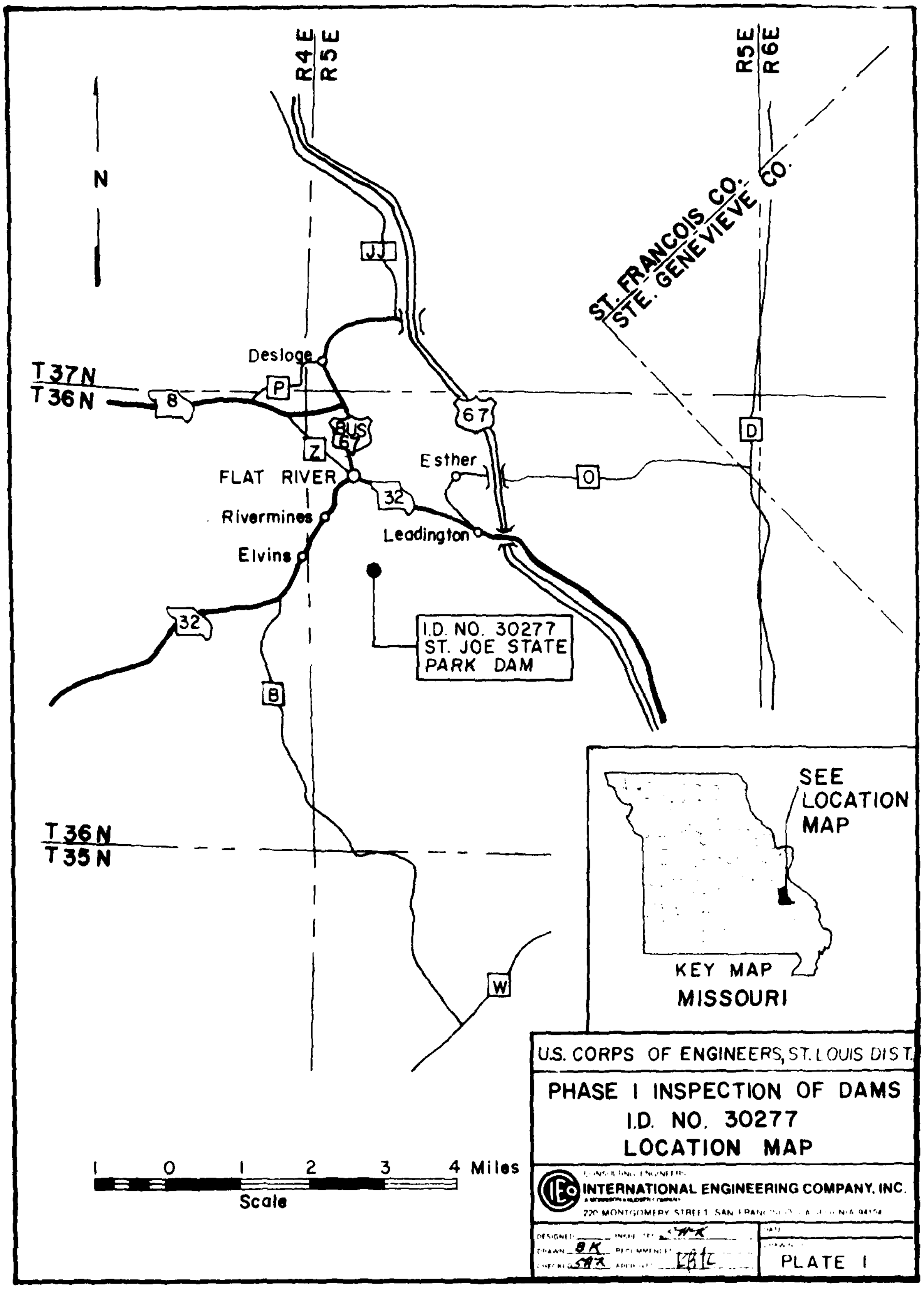
ABRIDGED
MODIFIED MERCALLI INTENSITY SCALE

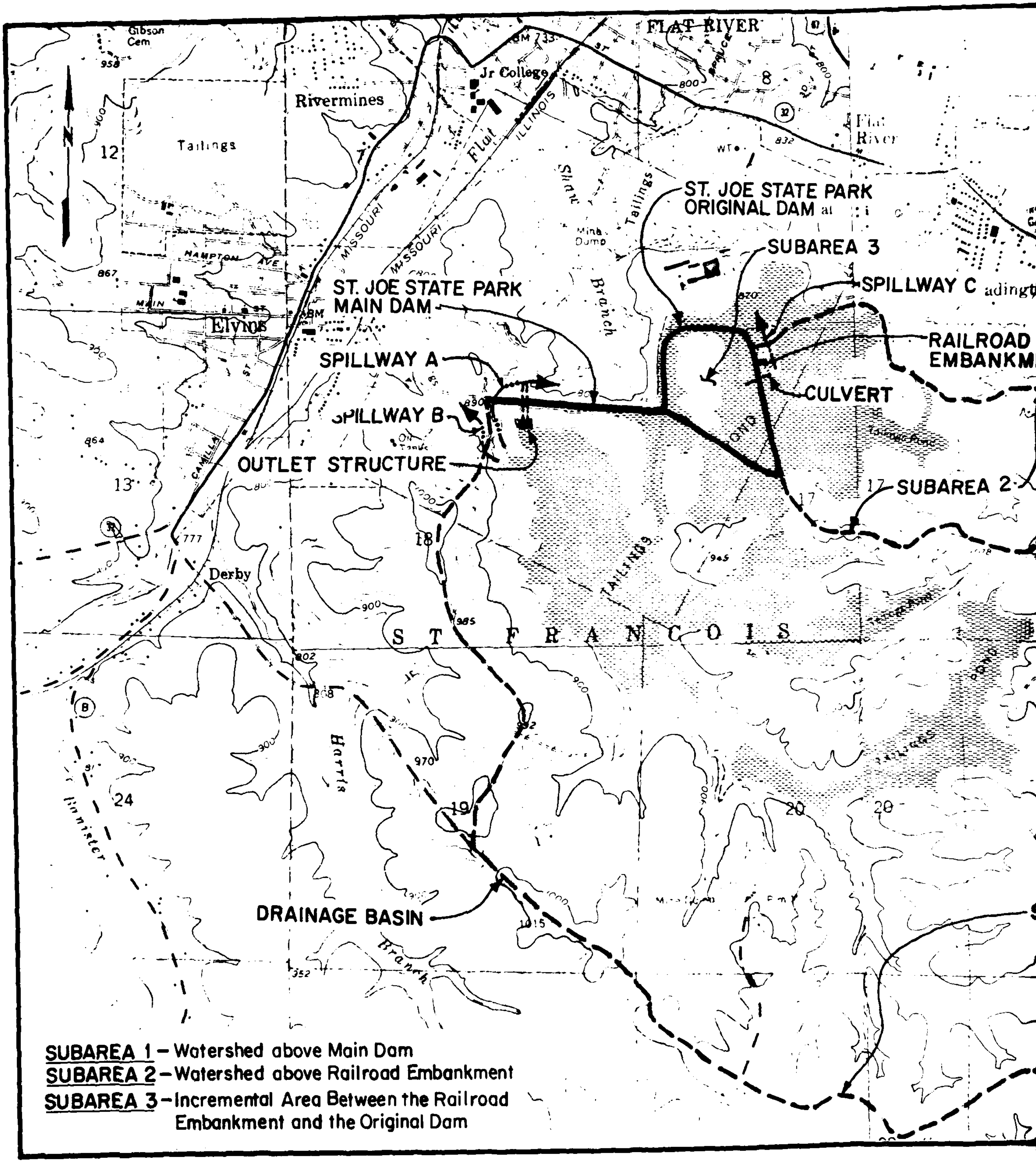
I	Not felt except by a very few under especially favourable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognise it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck Duration estimated.
IV	During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop.
VI	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII	Everybody runs outdoors. Damage **negligible** in buildings of good design and construction; **slight** to moderate in well-built ordinary structures; **considerable** in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
VIII	Damage **slight** in specially designed structures; **considerable** in ordinary substantial buildings with partial collapse; **great** in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.
IX	Damage **considerable** in specially designed structures, well designed frame structures thrown out of plumb; **great** in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations, ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

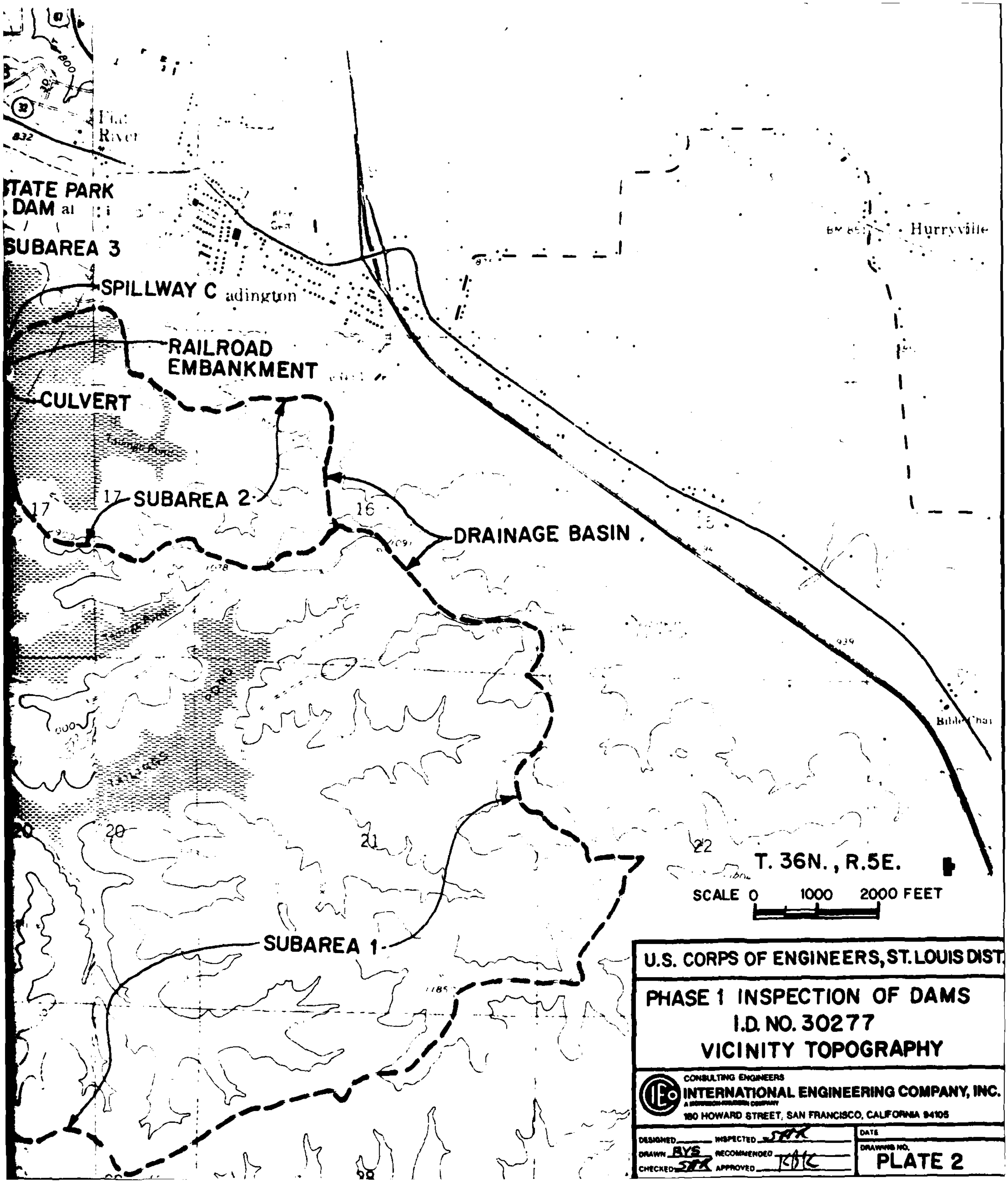


Modified Mercalli Intensity Scale after Wood and Neumann, 1931. (Intensities XI and XII not included).

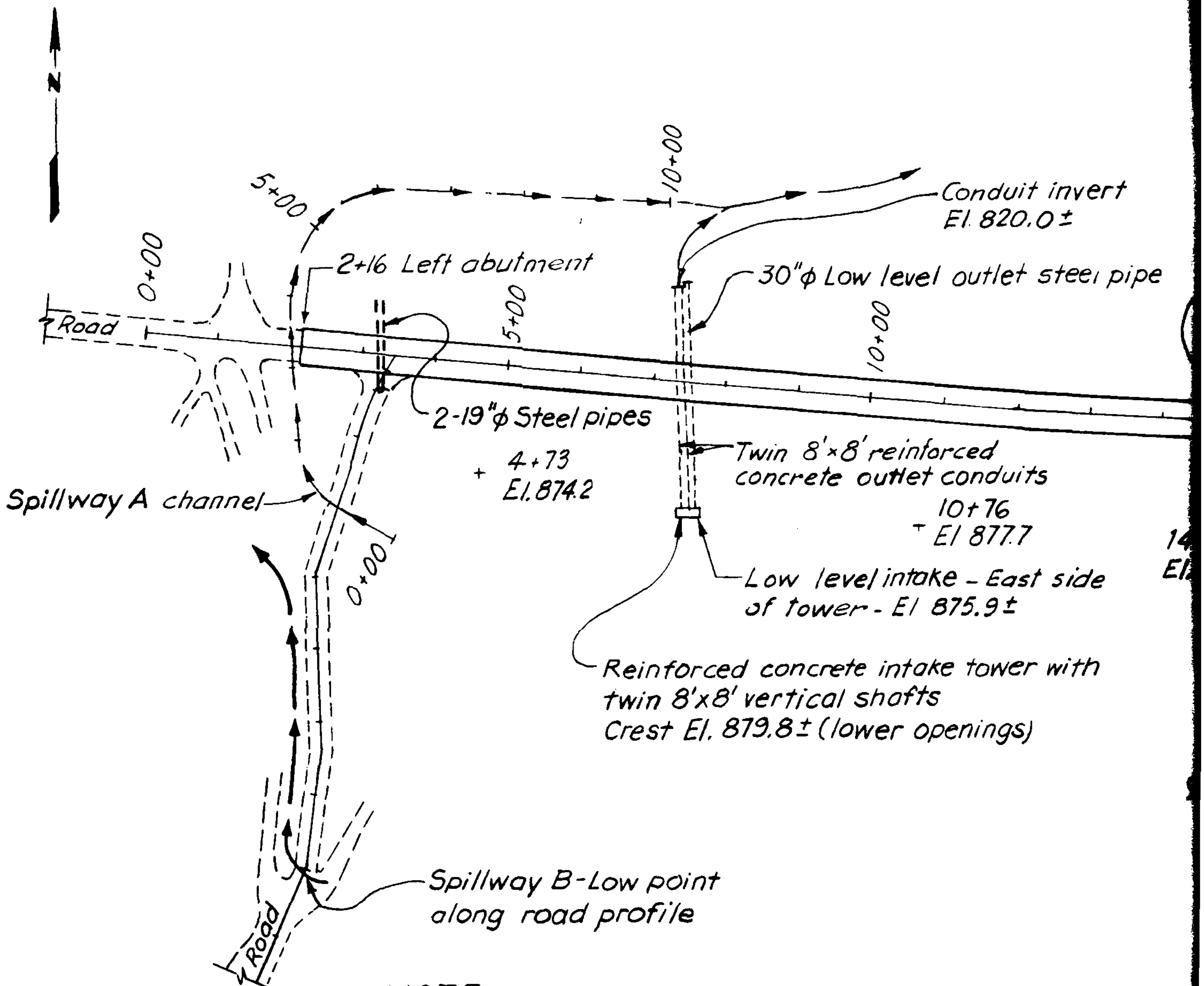
Magnitude and acceleration values taken from Nuclear Reactors and Earthquakes, TID-7024, United States Atomic Energy Commission.


R4E
R5E
R5E
R6E
N
ST. FRANCOIS CO.
STE. GENEVIEVE CO.
JJ
Desloge
T37N
T36N
P
8
BUS
67
67
Z
FLAT RIVER
Esther
O
D
32
Rivermines
Leadington
Elvins
32
I.D. NO. 30277
ST. JOE STATE
PARK DAM
B
T36N
T35N
W
SEE
LOCATION
MAP
KEY MAP
MISSOURI
1 0 1 2 3 4 Miles
Scale
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
LOCATION MAP
INTERNATIONAL ENGINEERING COMPANY, INC.
PLATE I


FLAT RIVER
Gibson Cem
Jr College
Rivermines
Tailings
Elvins
HAMPTON AVE
MAIN ST
MISSOURI
ILLINOIS
Flat
Shaft Branch
Mine Dump
Tailings
Flat River
ST. JOE STATE PARK ORIGINAL DAM
SUBAREA 3
SPILLWAY C
RAILROAD EMBANKMENT
CULVERT
ST. JOE STATE PARK MAIN DAM
SPILLWAY A
SPILLWAY B
OUTLET STRUCTURE
SUBAREA 2
Derby
S T F R A N C O I S
TAILINGS
Harris Branch
Bannister
DRAINAGE BASIN
SUBAREA 1 — Watershed above Main Dam
SUBAREA 2 — Watershed above Railroad Embankment
SUBAREA 3 — Incremental Area Between the Railroad Embankment and the Original Dam

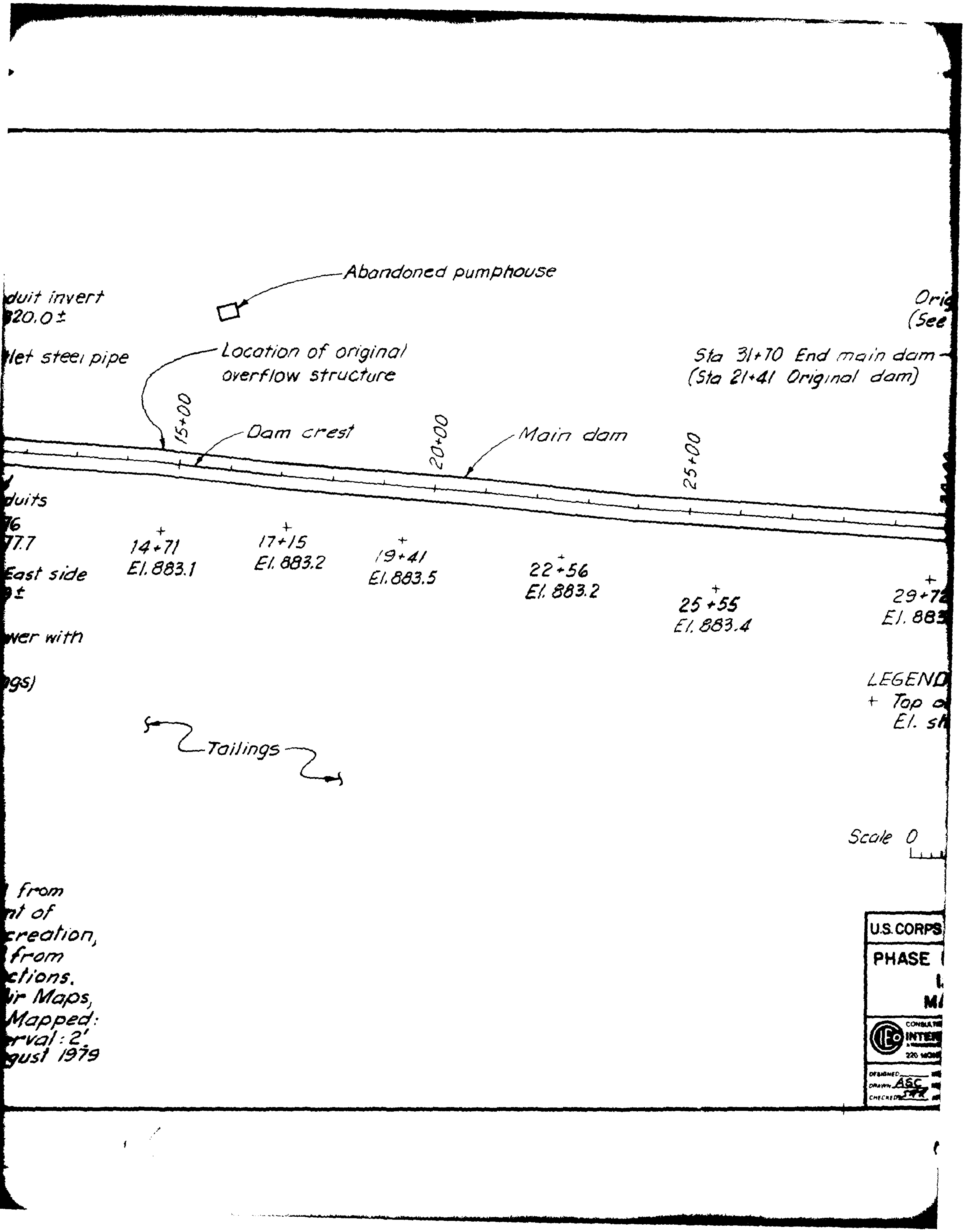


STATE PARK
DAM
SUBAREA 3
SPILLWAY C
RAILROAD
EMBANKMENT
CULVERT
SUBAREA 2
DRAINAGE BASIN
SUBAREA 1
Flat River
Hurryville
T. 36N., R.5E.
SCALE 0 1000 2000 FEET
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.
PHASE 1 INSPECTION OF DAMS
I.D. NO. 30277
VICINITY TOPOGRAPHY
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105
DESIGNED
INSPECTED
DRAWN BYS
RECOMMENDED
CHECKED
APPROVED
DATE
DRAWING NO.
PLATE 2

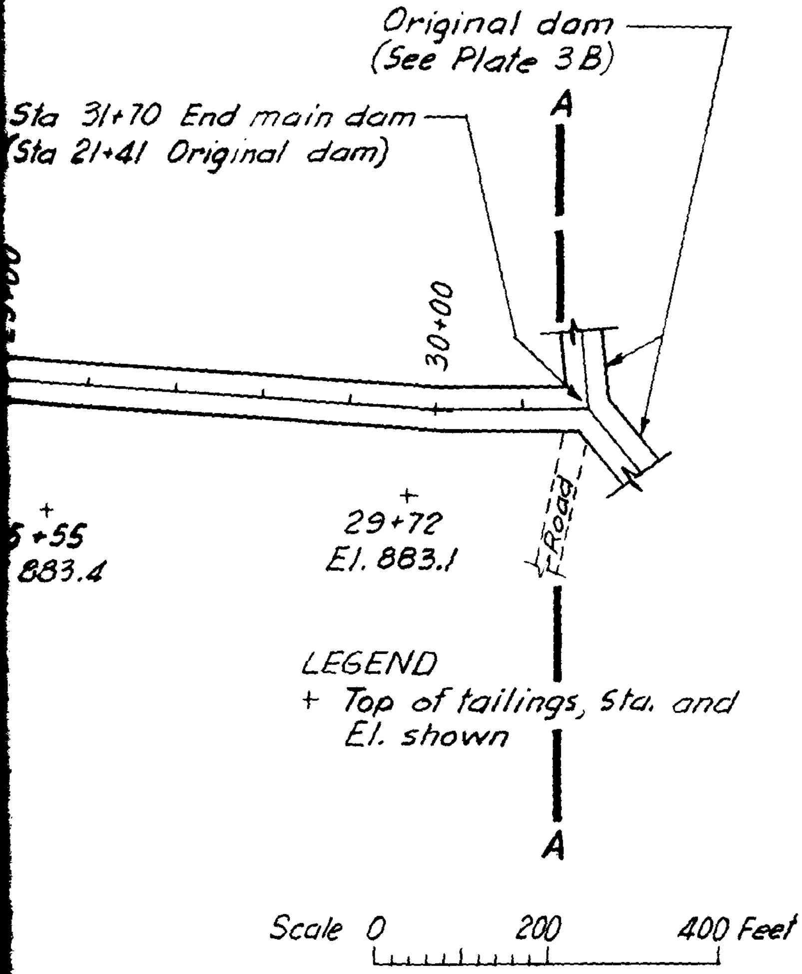


NOTE:

Plan, profile, and cross sections prepared from information taken from Missouri Department of Natural Resources, Division of Parks and Recreation, St. Joe State Park Topographic Maps and from information obtained during field inspections. Topographic maps compiled by Western Air Maps, Inc., Lenexa, Kansas. Flown: April 1976, Mapped: May 1976, Scale: 1" = 100', contour interval: 2'. Date of field inspection: 25 and 26 August 1979



Abandoned pumphouse
duit invert
320.0±
let steel pipe
Location of original
overflow structure
Sta 31+70 End main dam
(Sta 21+41 Original dam)
15+00
Dam crest
20+00
Main dam
25+00
duits
14+71
El. 883.1
17+15
El. 883.2
19+41
El. 883.5
22+56
El. 883.2
25+55
El. 883.4
29+72
East side
wer with
gs)
LEGEND
+ Top
El.
Tailings
Scale 0
from
nt of
creation,
from
ctions.
ir Maps,
Mapped:
rval: 2'
gust 1979
U.S. CORPS
PHASE
DRAWN ASC

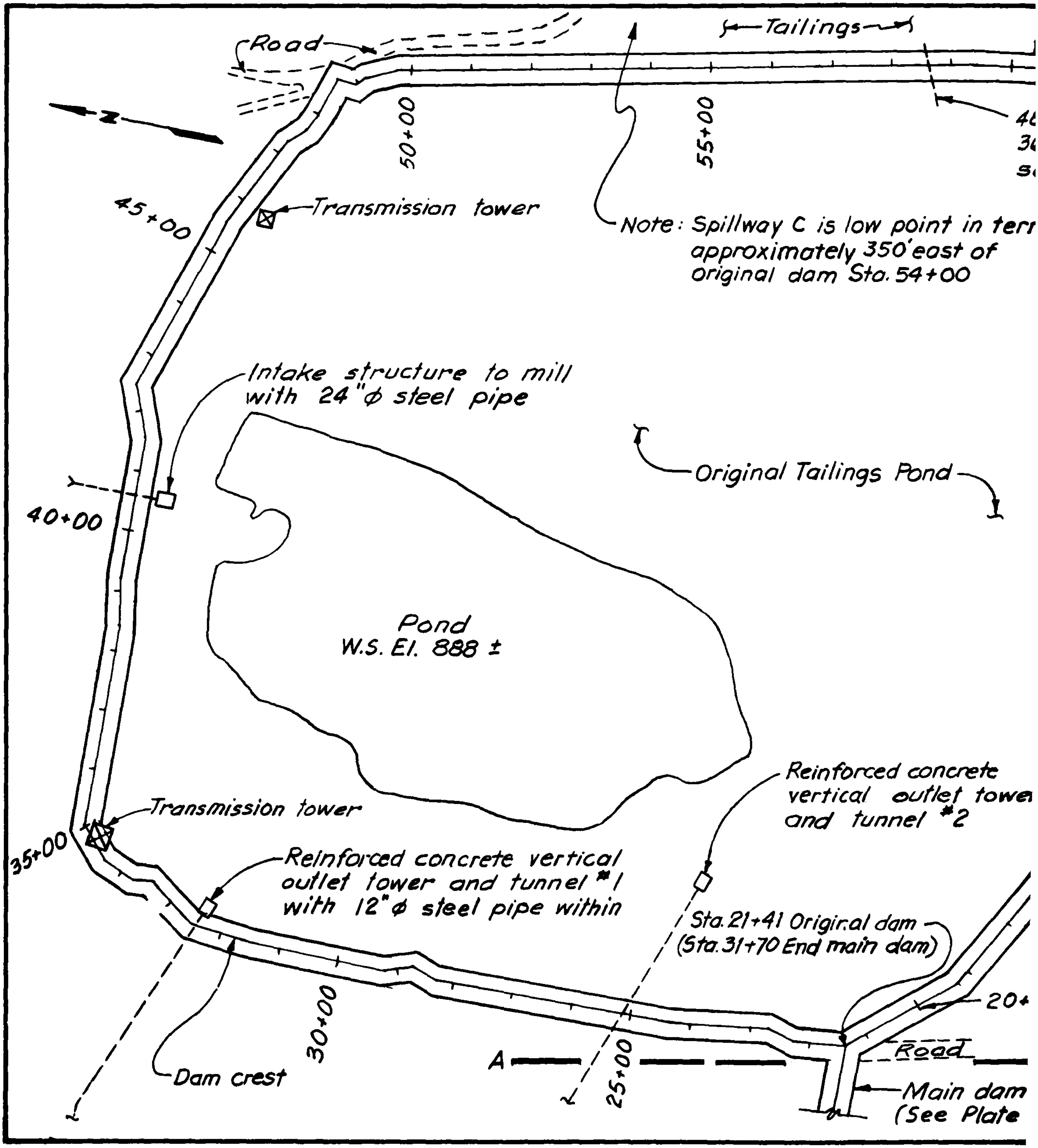


U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

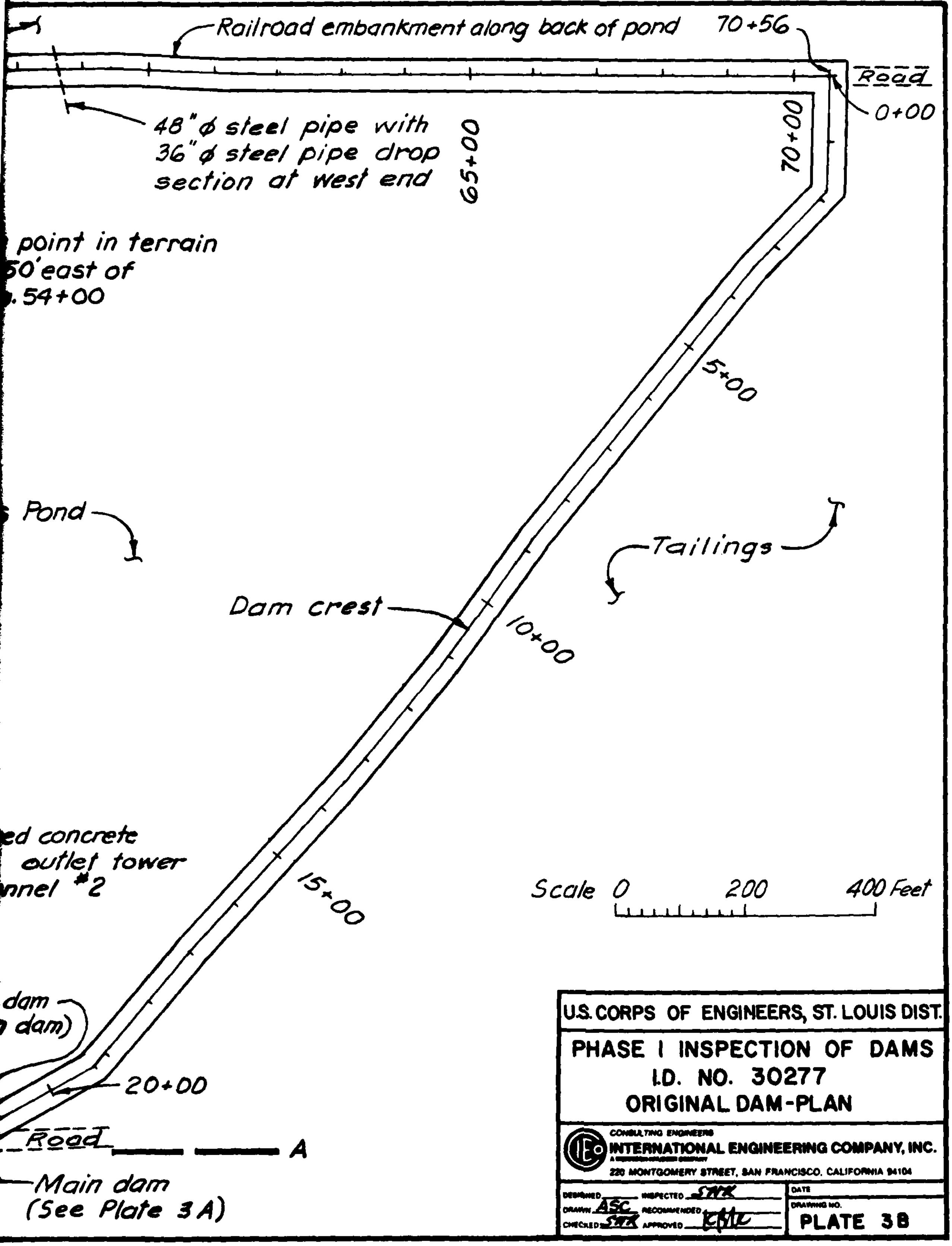
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
MAIN DAM – PLAN

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

DESIGNED ____ INSPECTED SWR
DRAWN ASC RECOMMENDED
CHECKED SWR APPROVED KBK
DATE
DRAWING NO. PLATE 3A



Road
Tailings
N
50+00
55+00
45+00
Transmission tower
Note: Spillway C is low point in ter
approximately 350' east of
original dam Sta. 54+00
Intake structure to mill
with 24" ϕ steel pipe
Original Tailings Pond
40+00
Pond
W.S. El. 888 ±
Reinforced concrete
vertical outlet towe
and tunnel #2
Transmission tower
35+00
Reinforced concrete vertical
outlet tower and tunnel #1
with 12" ϕ steel pipe within
Sta. 21+41 Original dam
(Sta. 31+70 End main dam)
20+
30+00
Road
A
25+00
Dam crest
Main dam
(See Plate

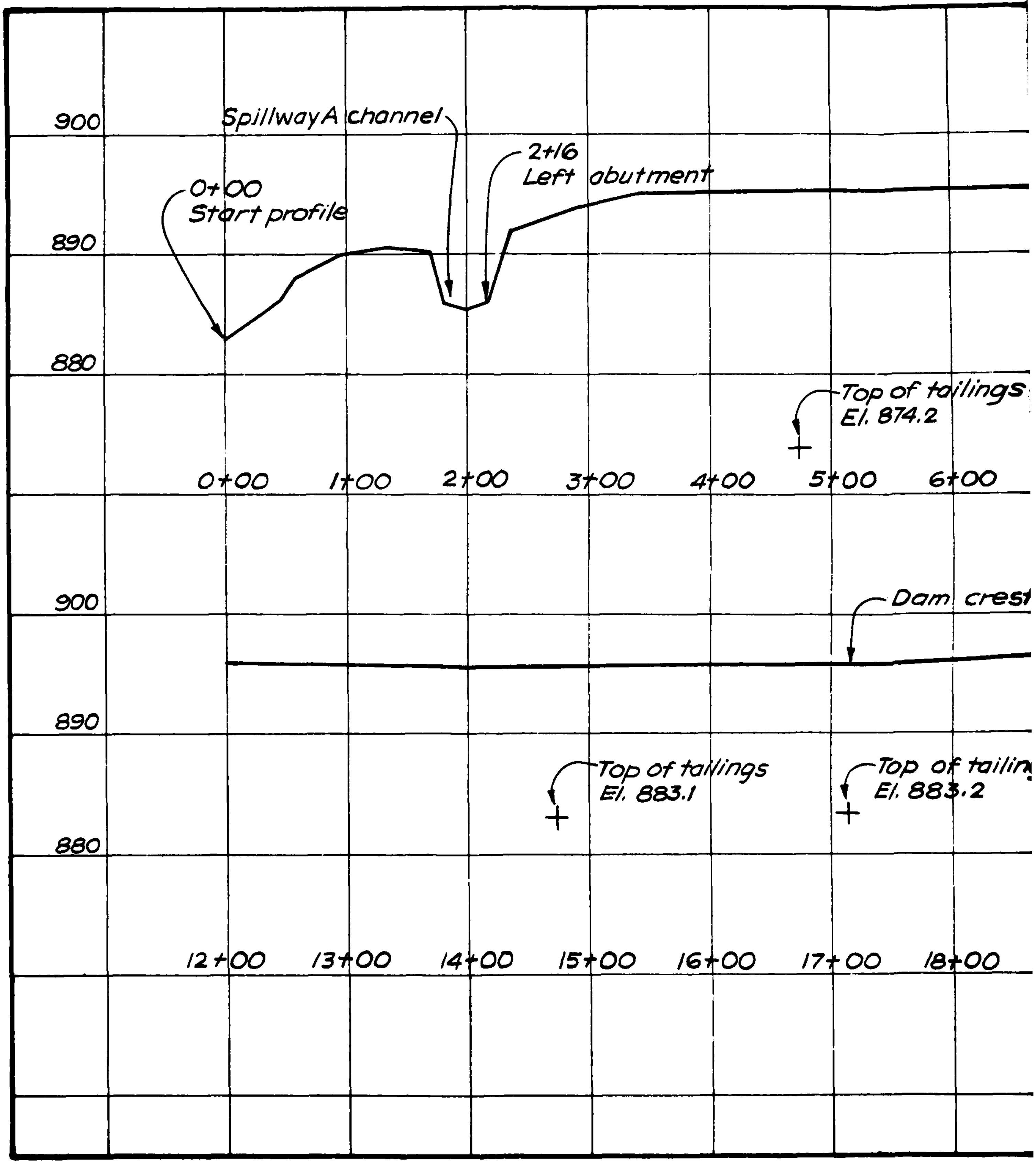


U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

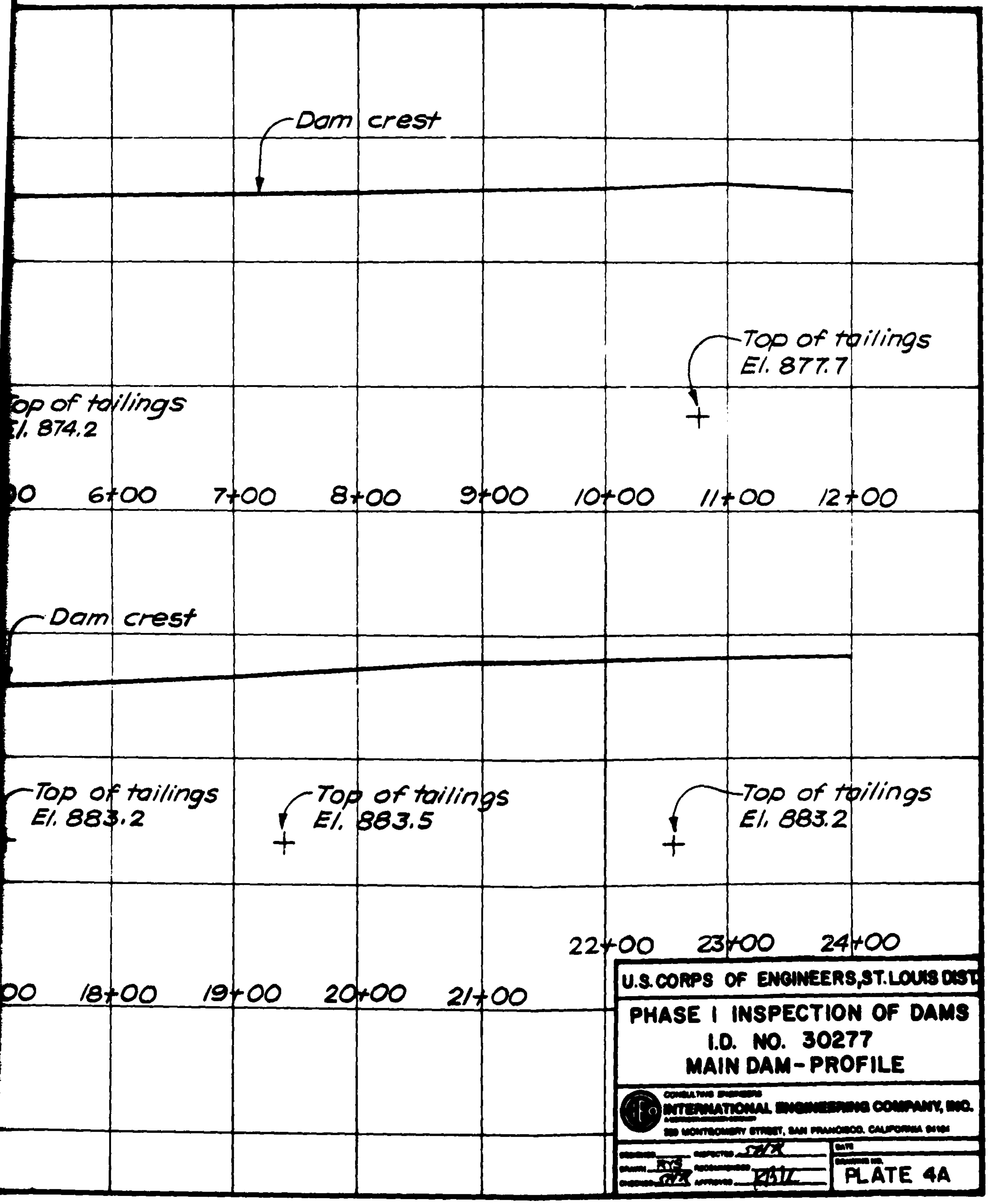
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
ORIGINAL DAM-PLAN

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

DESIGNED	INSPECTED SWK	DATE
DRAWN ASC	RECOMMENDED	DRAWING NO.
CHECKED SWK	APPROVED KML	PLATE 3B



900
890
880
Spillway A channel
2+16
Left abutment
0+00
Start profile
Top of tailings
El. 874.2
0+00
1+00
2+00
3+00
4+00
5+00
6+00
900
Dam crest
890
Top of tailings
El. 883.1
Top of tailing
El. 883.2
880
12+00
13+00
14+00
15+00
16+00
17+00
18+00

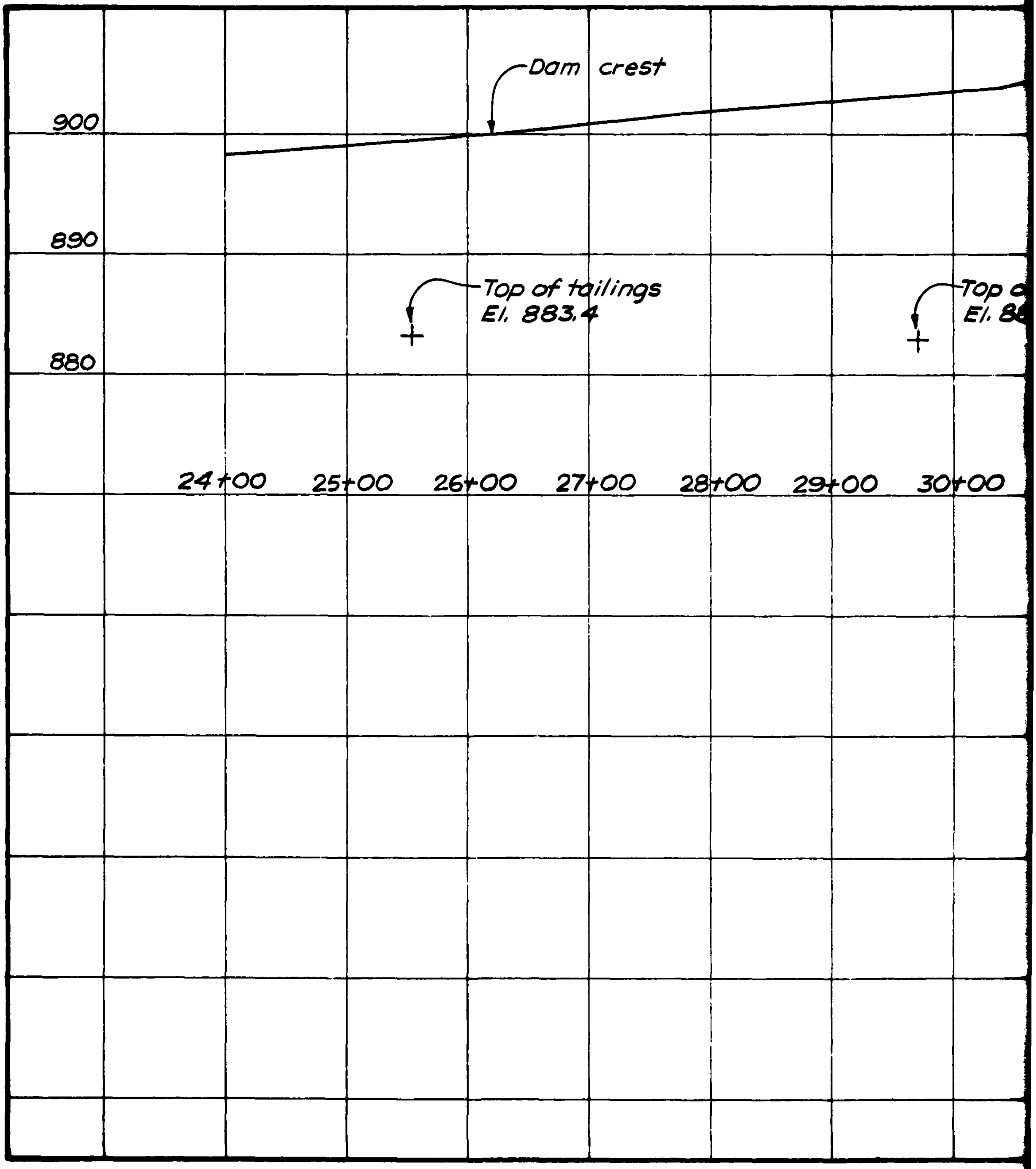


U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

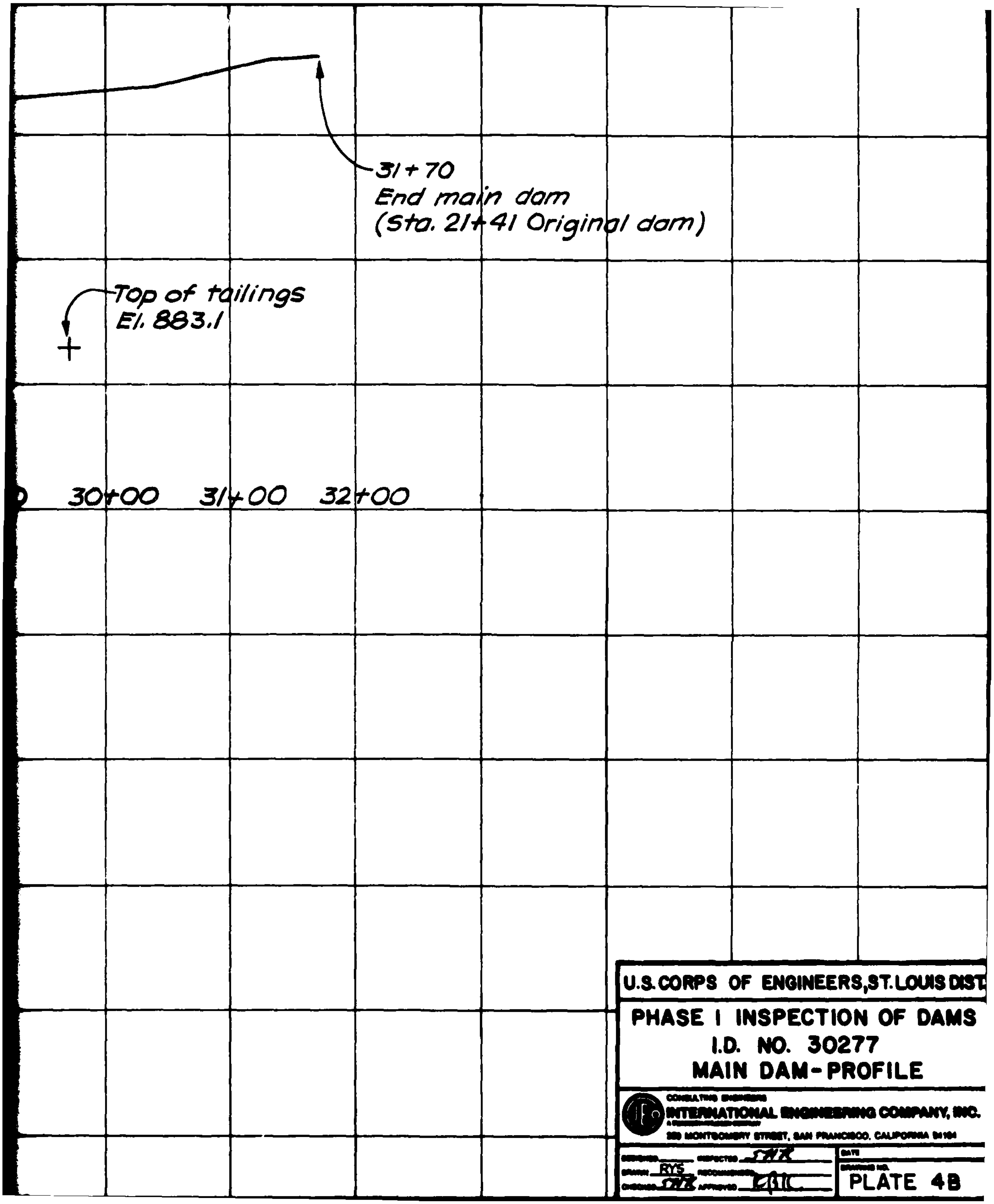
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
MAIN DAM-PROFILE

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

PLATE 4A



Dam crest
900
890
Top of tailings
El. 883.4
Top o
El. 88
880
24+00
25+00
26+00
27+00
28+00
29+00
30+00



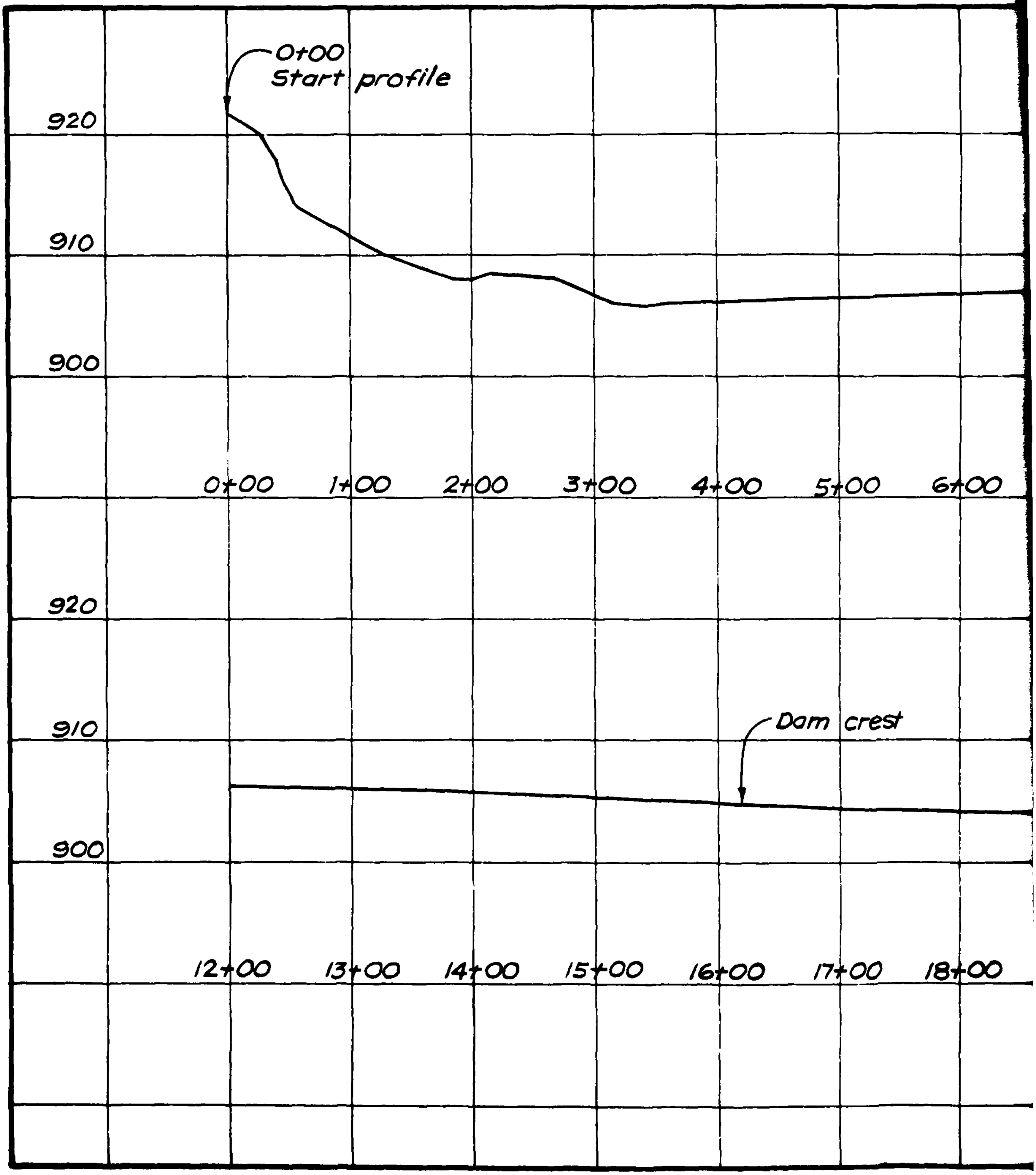
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

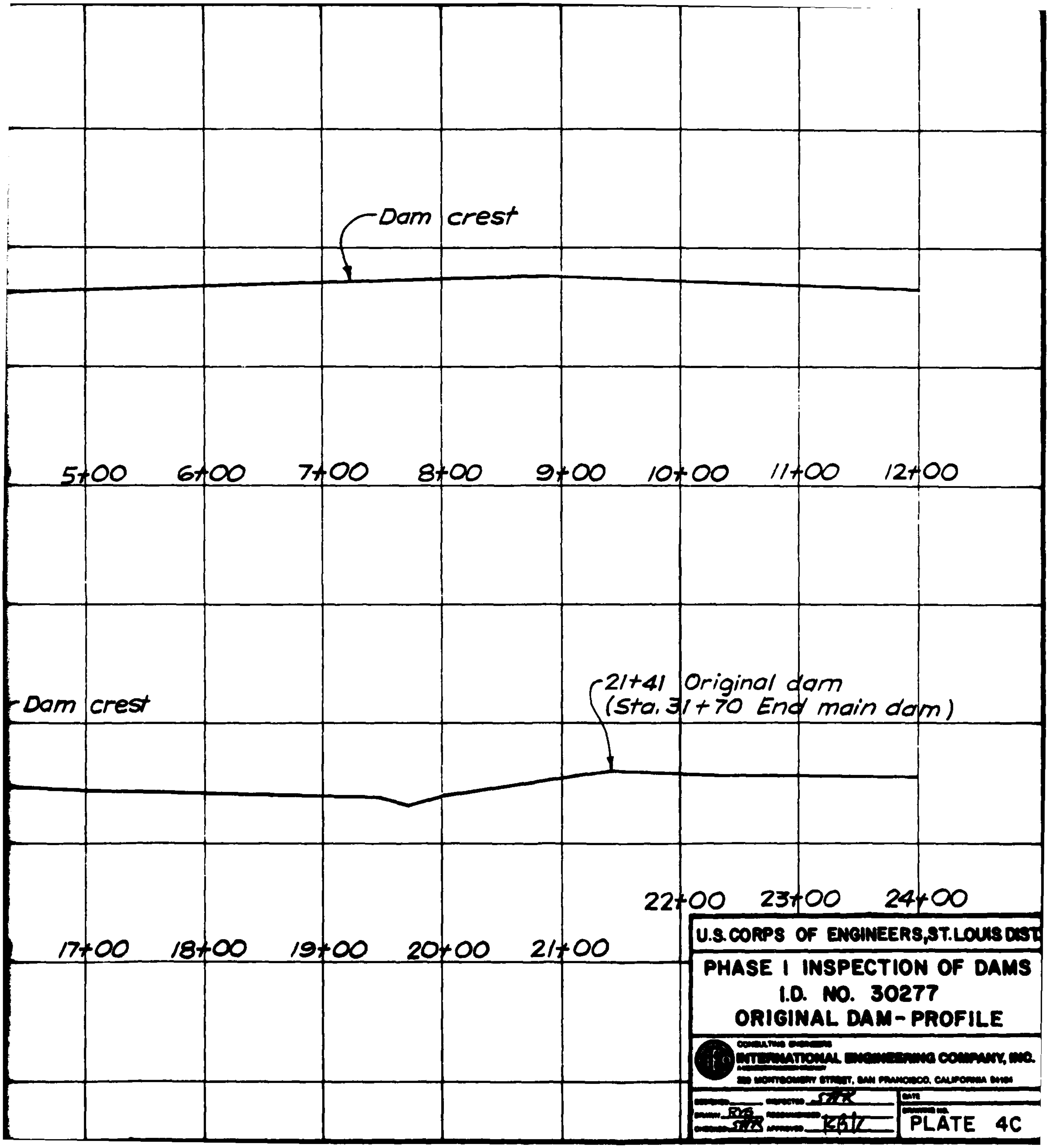
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
MAIN DAM-PROFILE

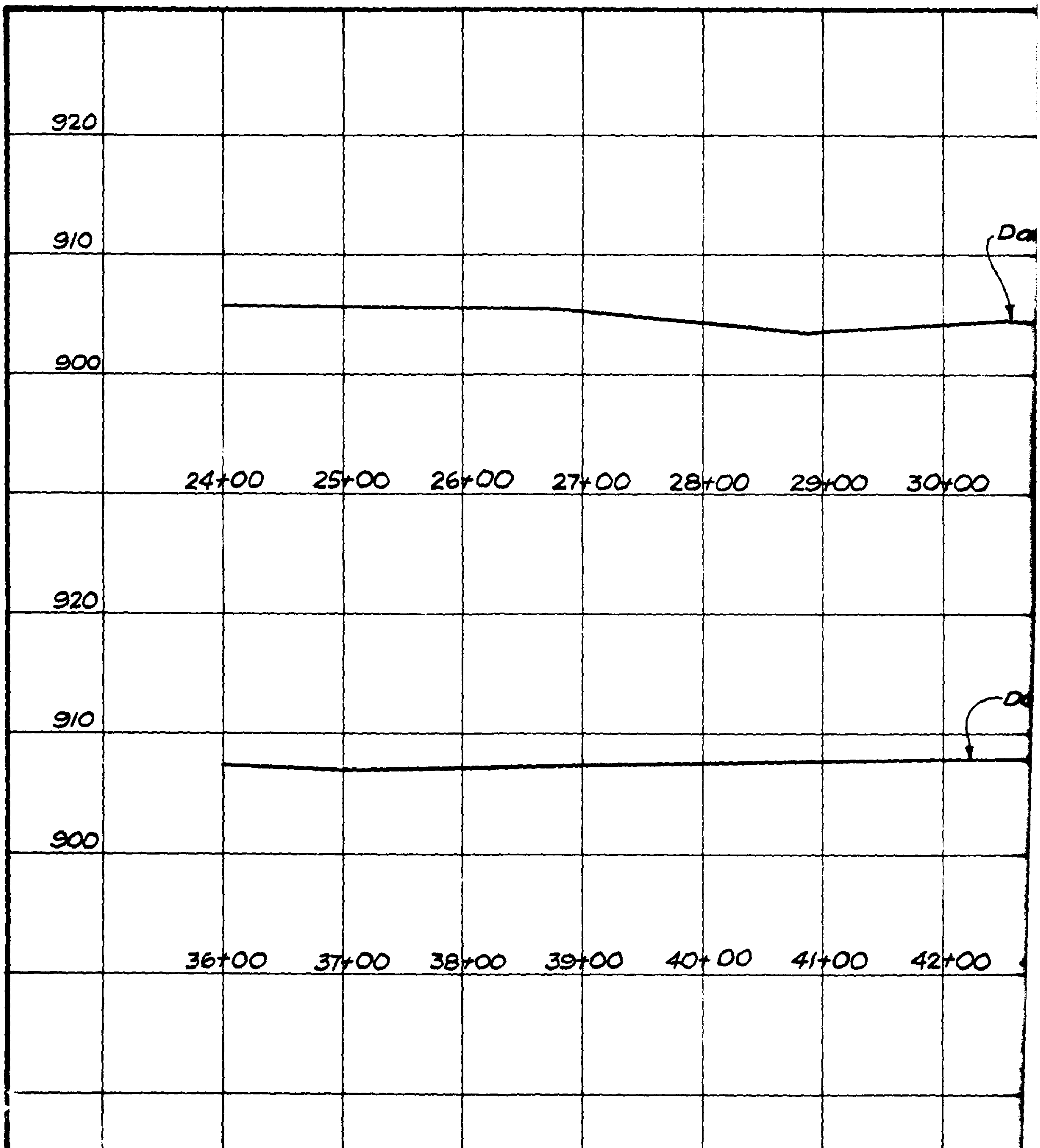
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA

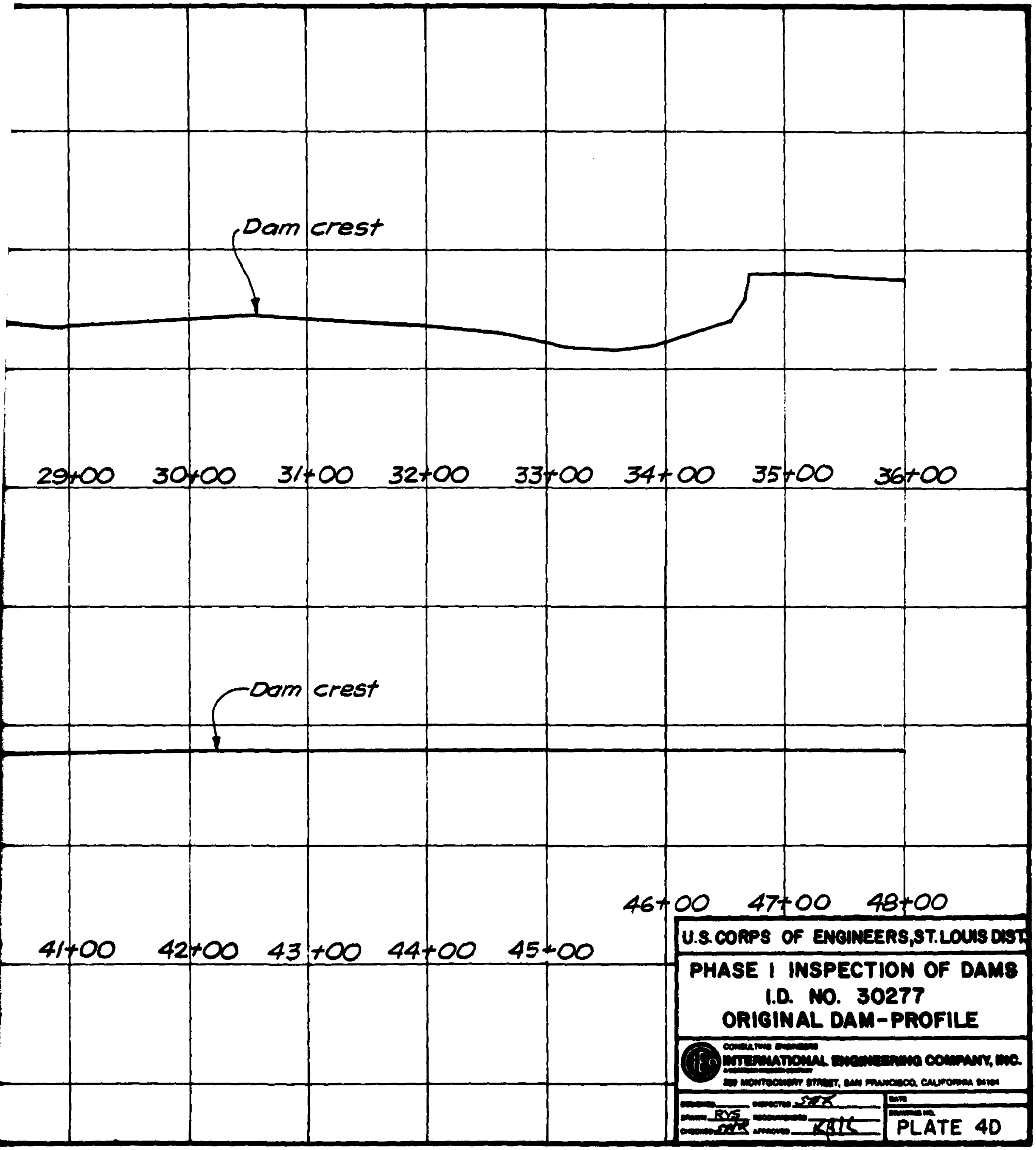
DRAWN RYS

PLATE 4B


0+00
Start profile
920
910
900
0+00
1+00
2+00
3+00
4+00
5+00
6+00
920
910
Dam crest
900
12+00
13+00
14+00
15+00
16+00
17+00
18+00


Dam crest
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
21+41 Original dam
(Sta. 31+70 End main dam)
Dam crest
22+00
23+00
24+00
17+00
18+00
19+00
20+00
21+00
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
ORIGINAL DAM - PROFILE
INTERNATIONAL ENGINEERING COMPANY, INC.
PLATE 4C


920
910
900
24+00
25+00
26+00
27+00
28+00
29+00
30+00
920
910
900
36+00
37+00
38+00
39+00
40+00
41+00
42+00



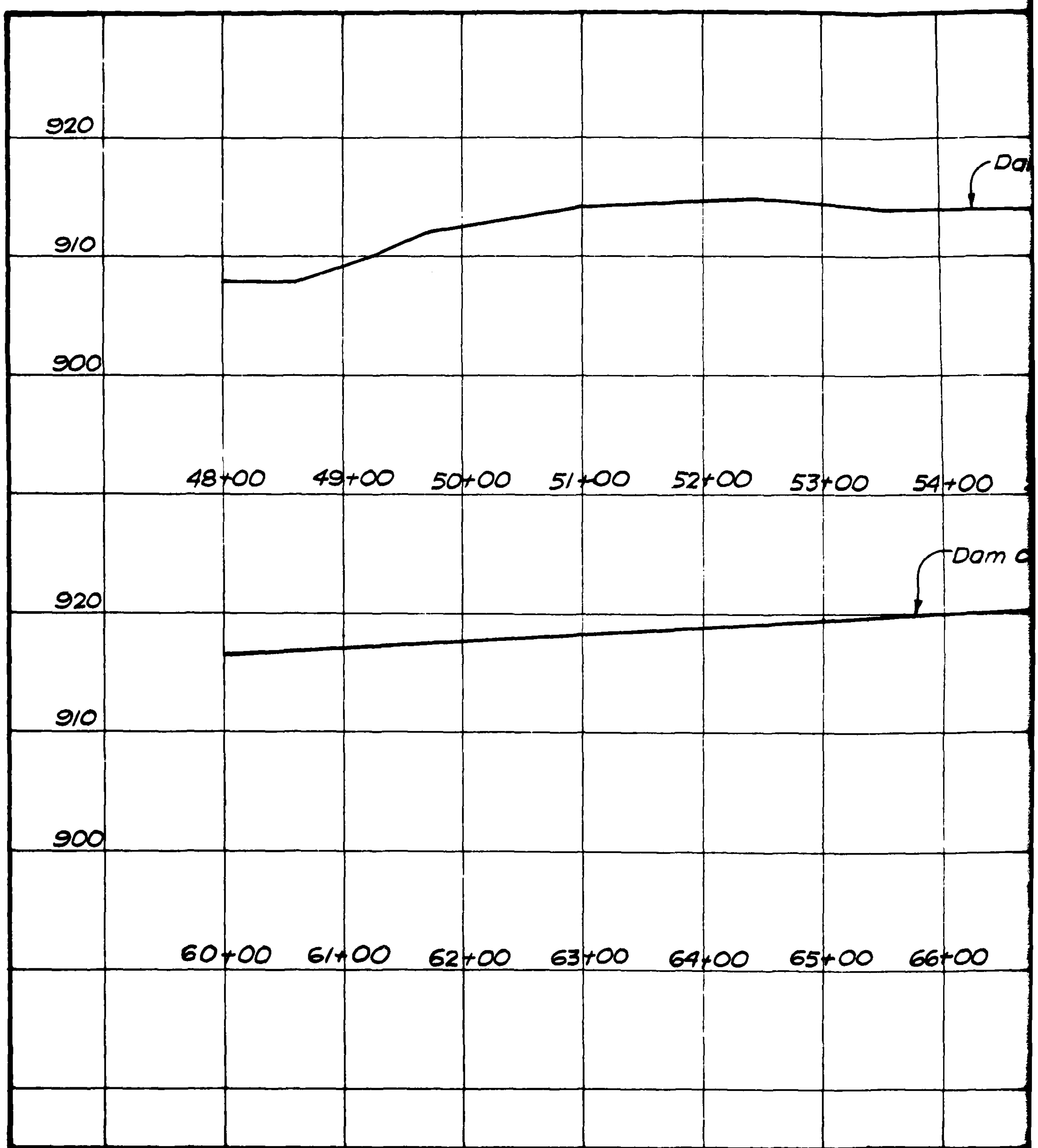
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

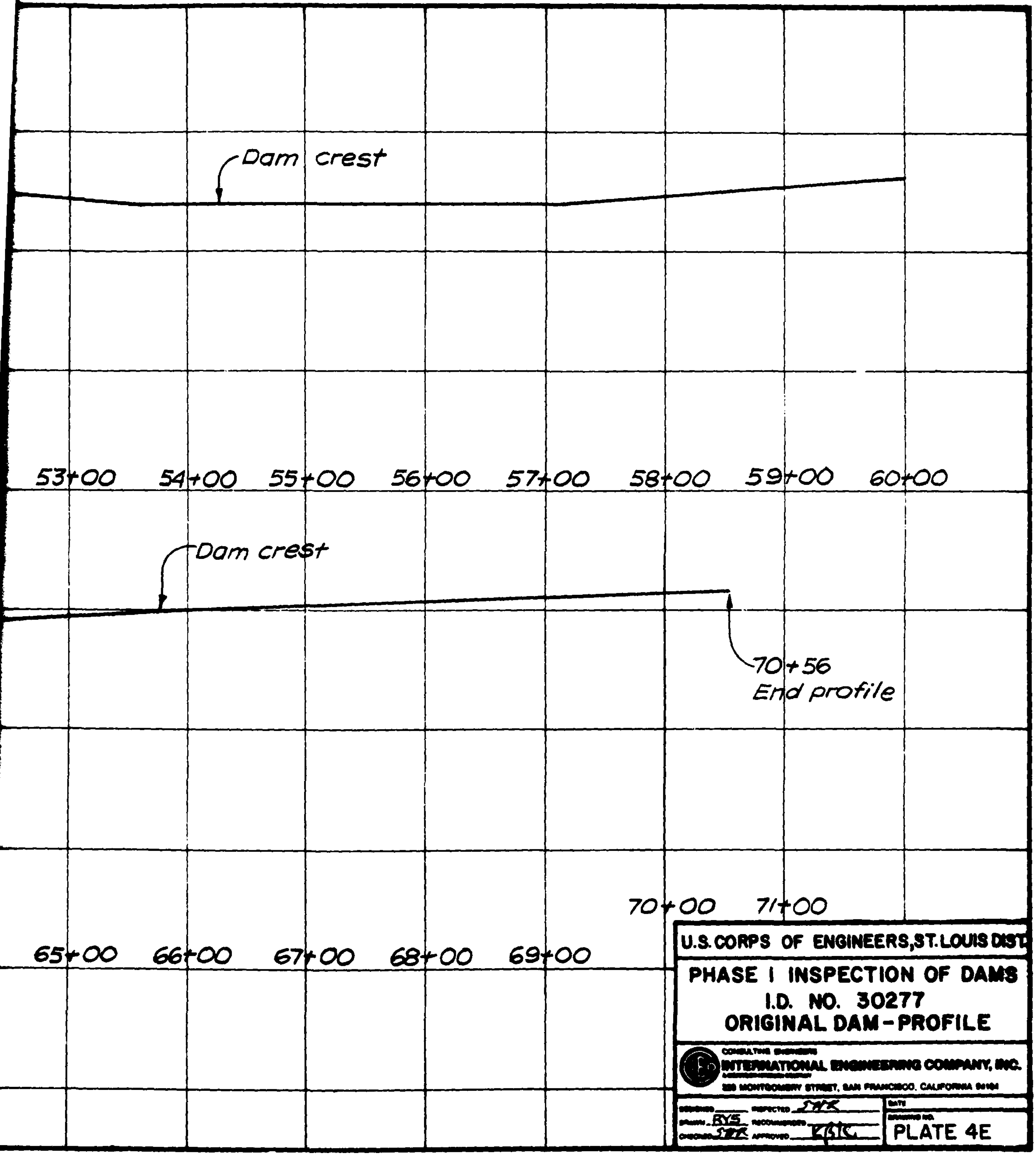
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
ORIGINAL DAM-PROFILE

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
SAN FRANCISCO, CALIFORNIA

INSPECTED SRK
DRAWN RYS
APPROVED KBIS

PLATE 4D


920
910
900
Da
48+00
49+00
50+00
51+00
52+00
53+00
54+00
920
910
900
Dam c
60+00
61+00
62+00
63+00
64+00
65+00
66+00



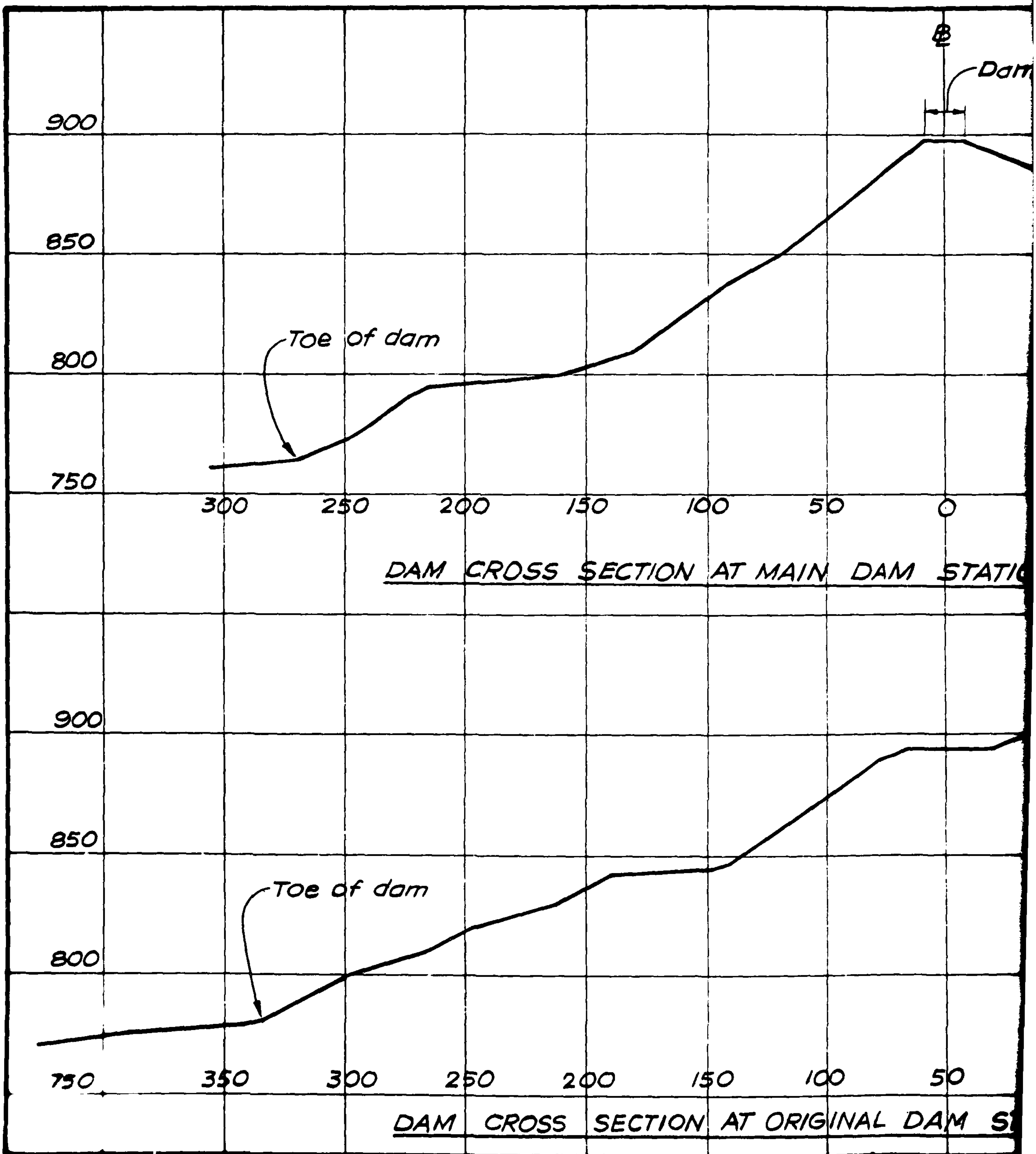
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
I.D. NO. 30277
ORIGINAL DAM-PROFILE

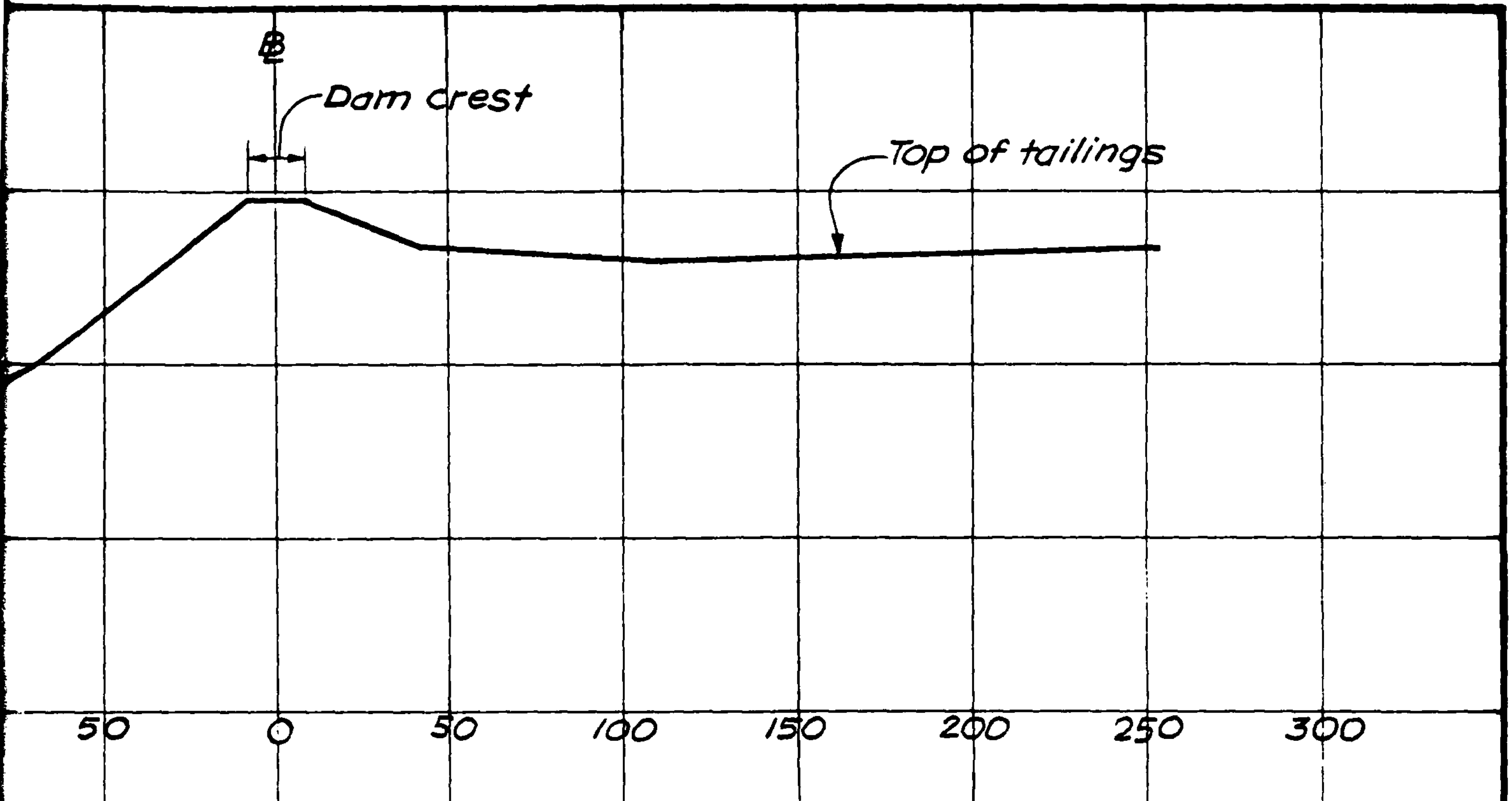
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA

DRAWN RYS
INSPECTED SWR
CHECKED SWR
APPROVED KBIC

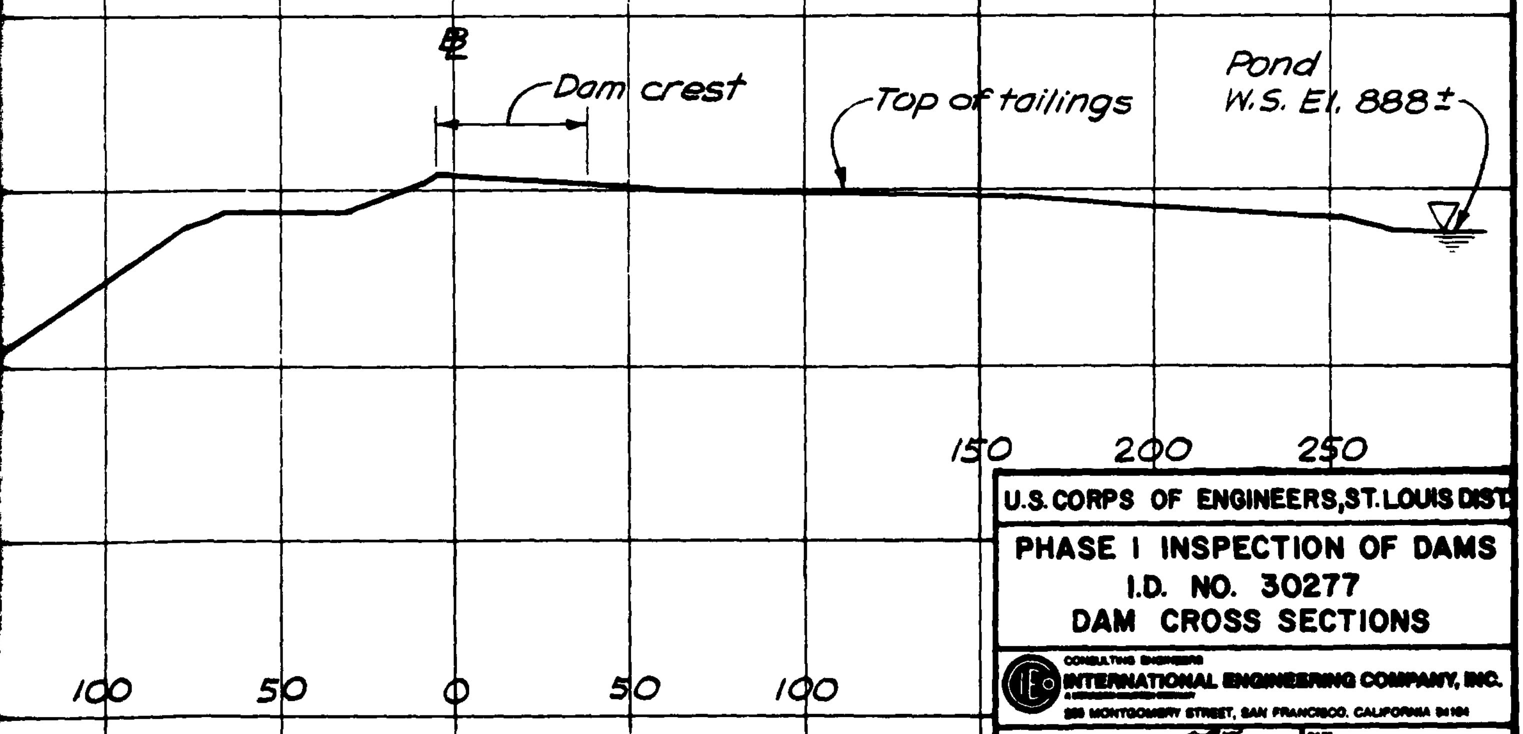
PLATE 4E



℄
Dam
900
850
800
750
Toe of dam
300
250
200
150
100
50
0
DAM CROSS SECTION AT MAIN DAM STATI
900
850
800
750
Toe of dam
350
300
250
200
150
100
50
DAM CROSS SECTION AT ORIGINAL DAM S



MAIN DAM STATION 20+82



ORIGINAL DAM STATION 26+86

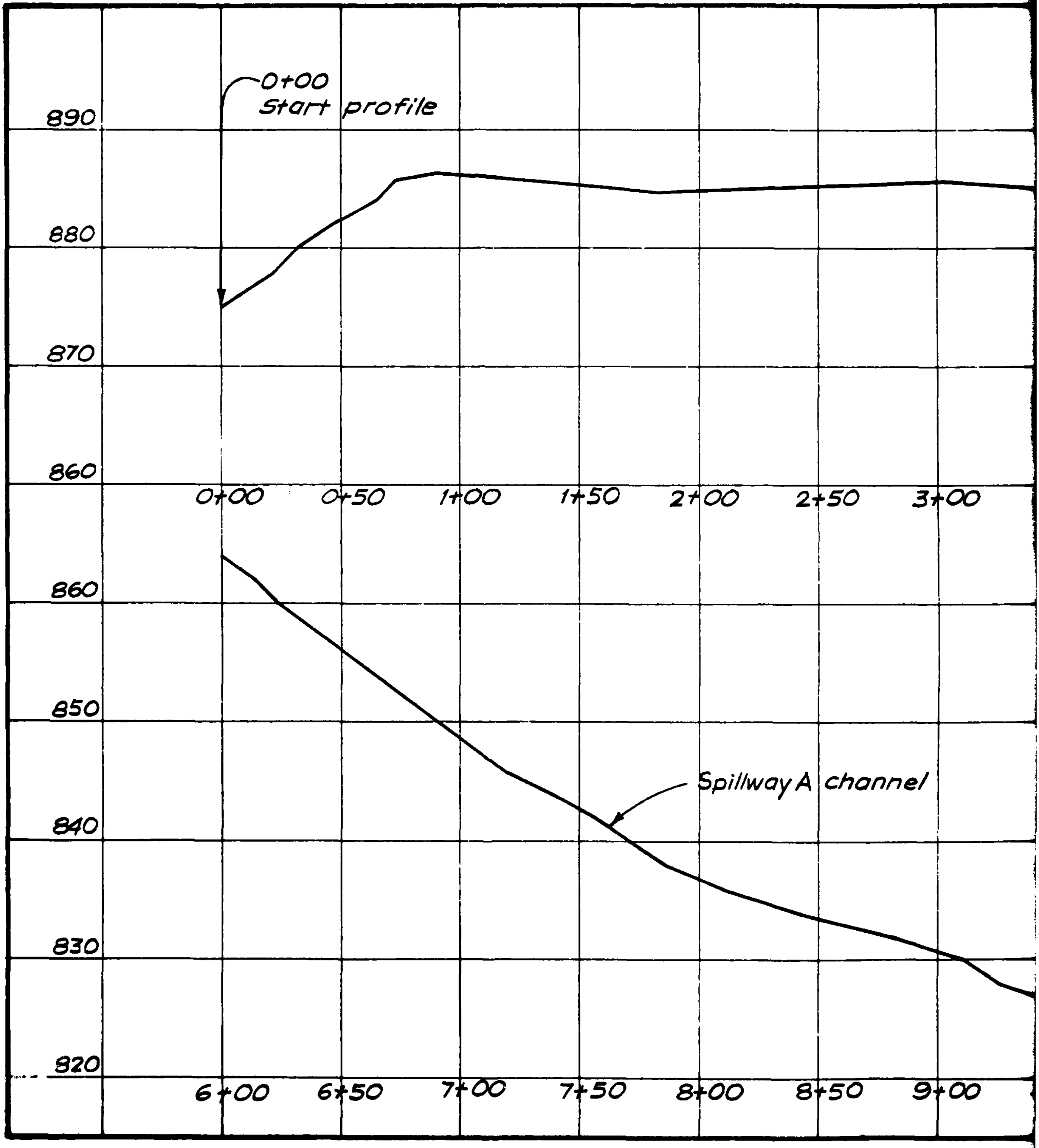
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

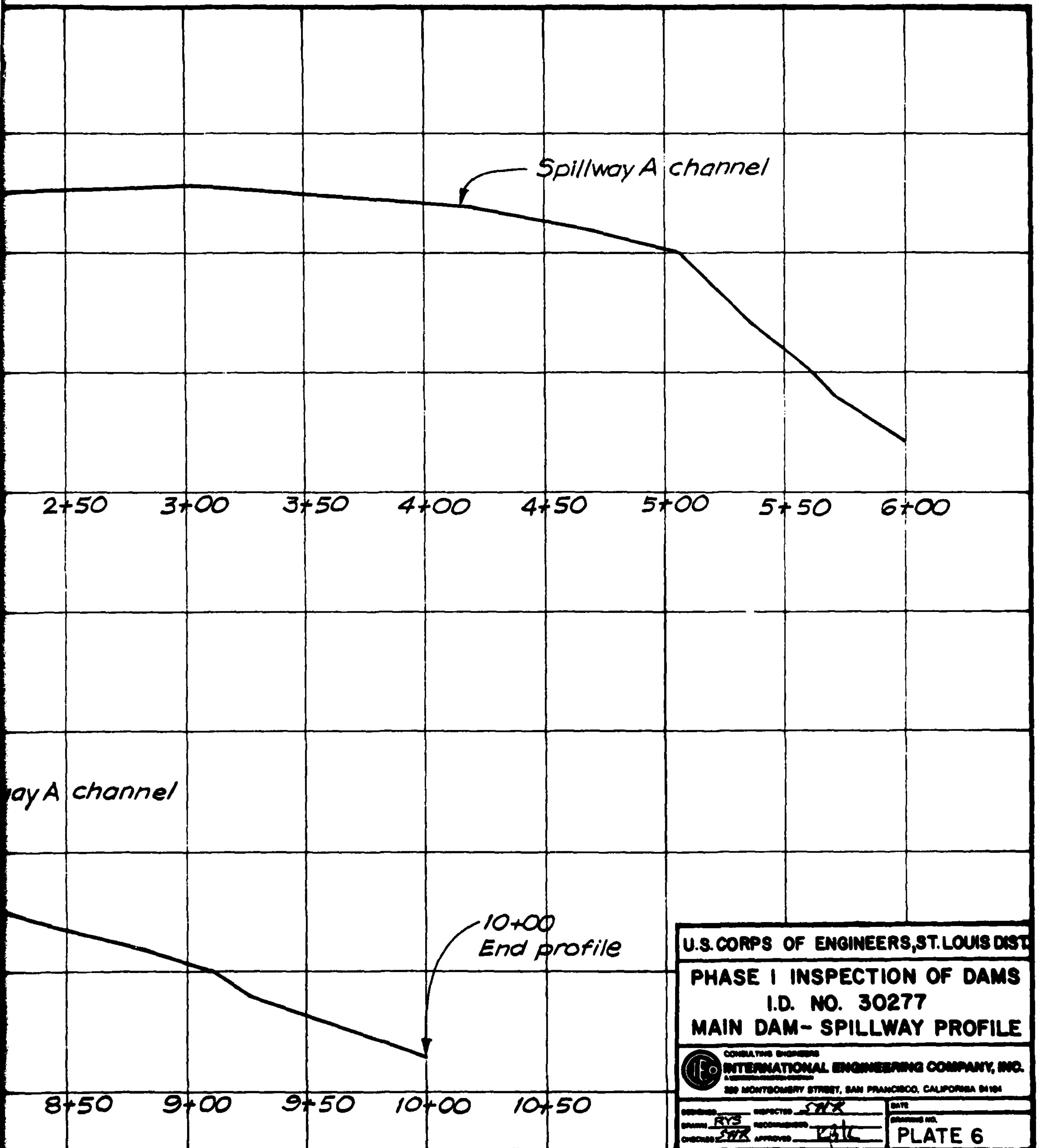
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
DAM CROSS SECTIONS

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA

DRAWN RYS
CHECKED SWK
INSPECTED SWK

PLATE 5


0+00
Start profile
890
880
870
860
0+00
0+50
1+00
1+50
2+00
2+50
3+00
860
850
840
830
820
Spillway A channel
6+00
6+50
7+00
7+50
8+00
8+50
9+00

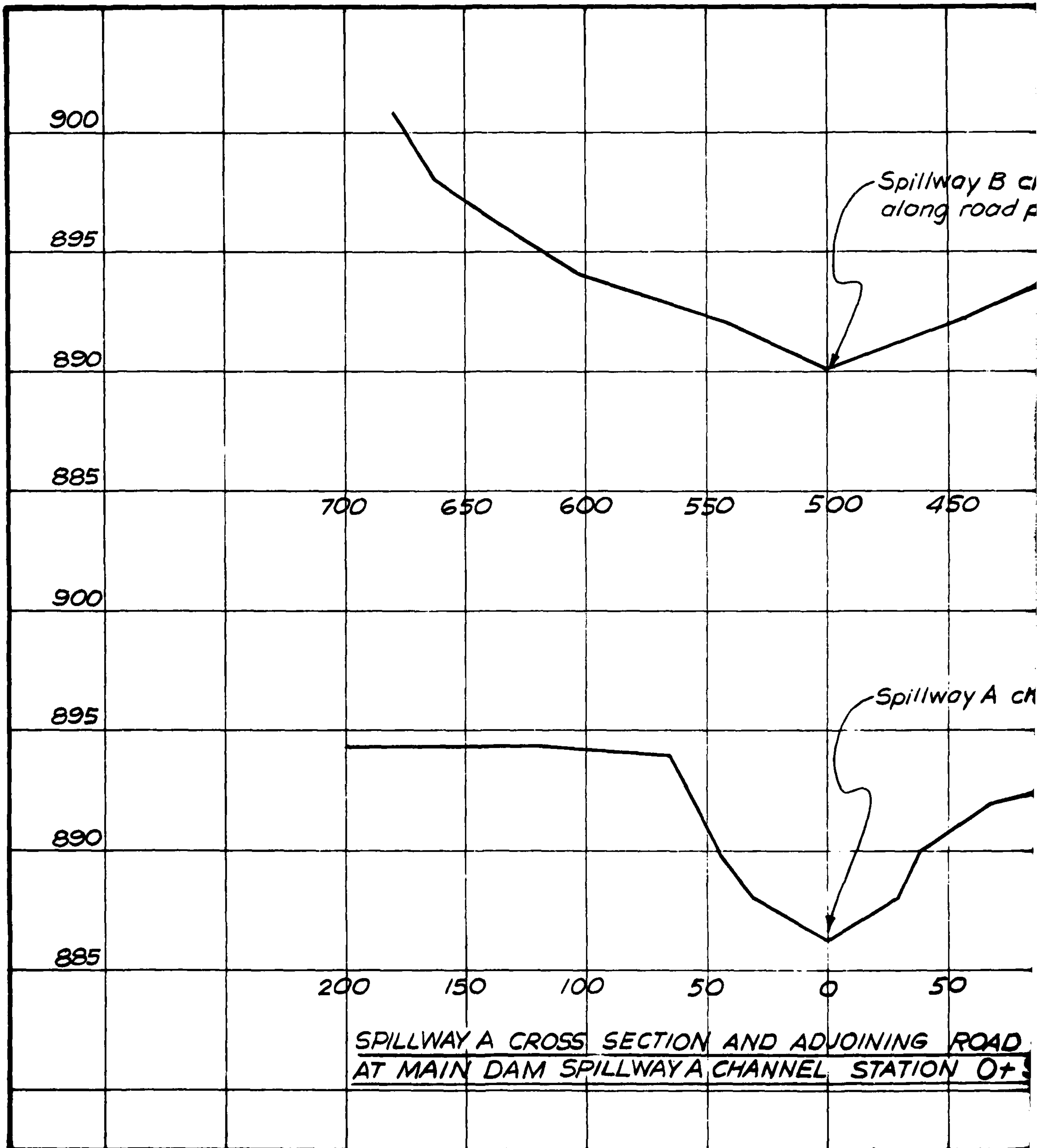


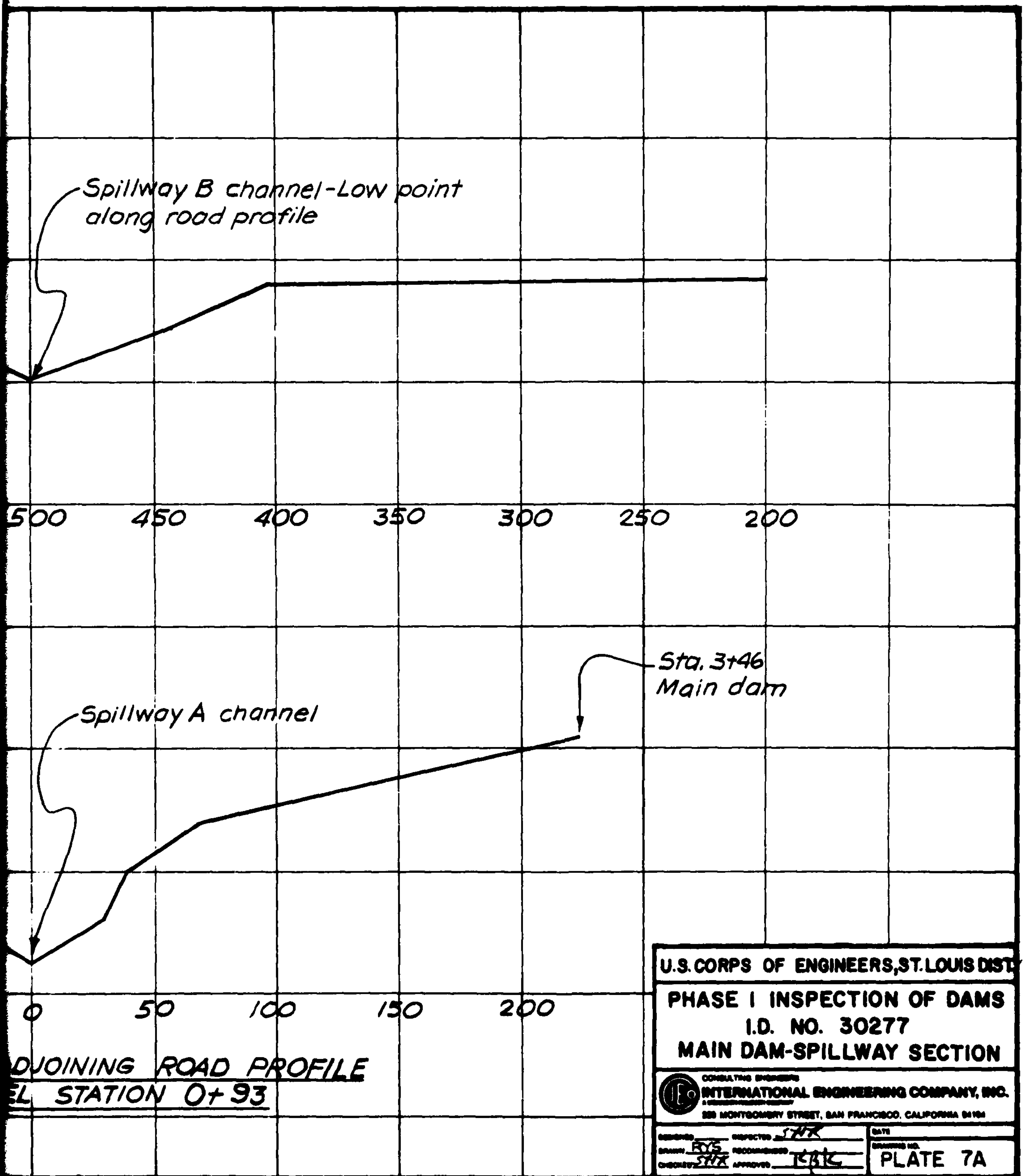
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
I.D. NO. 30277
MAIN DAM- SPILLWAY PROFILE

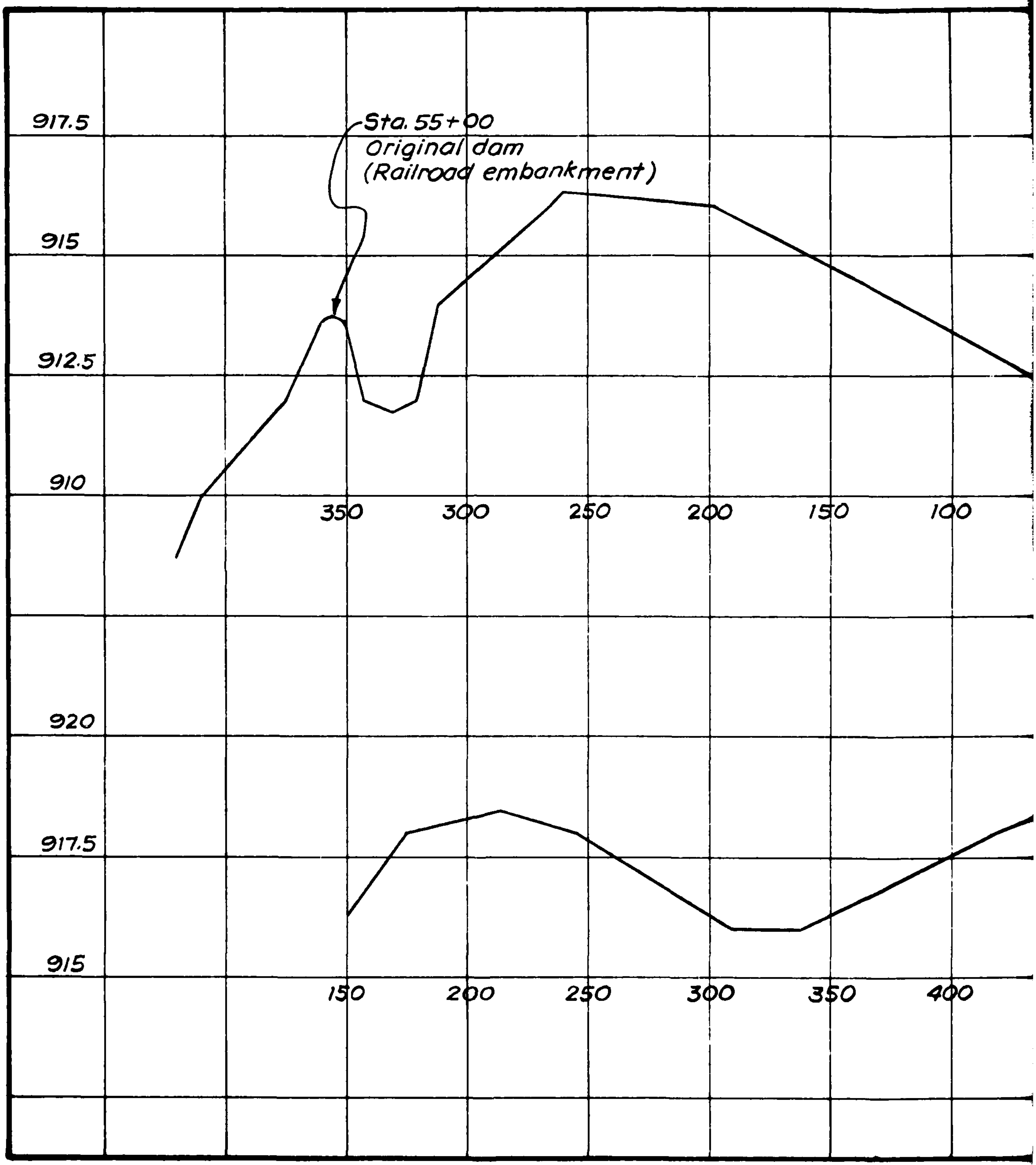
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

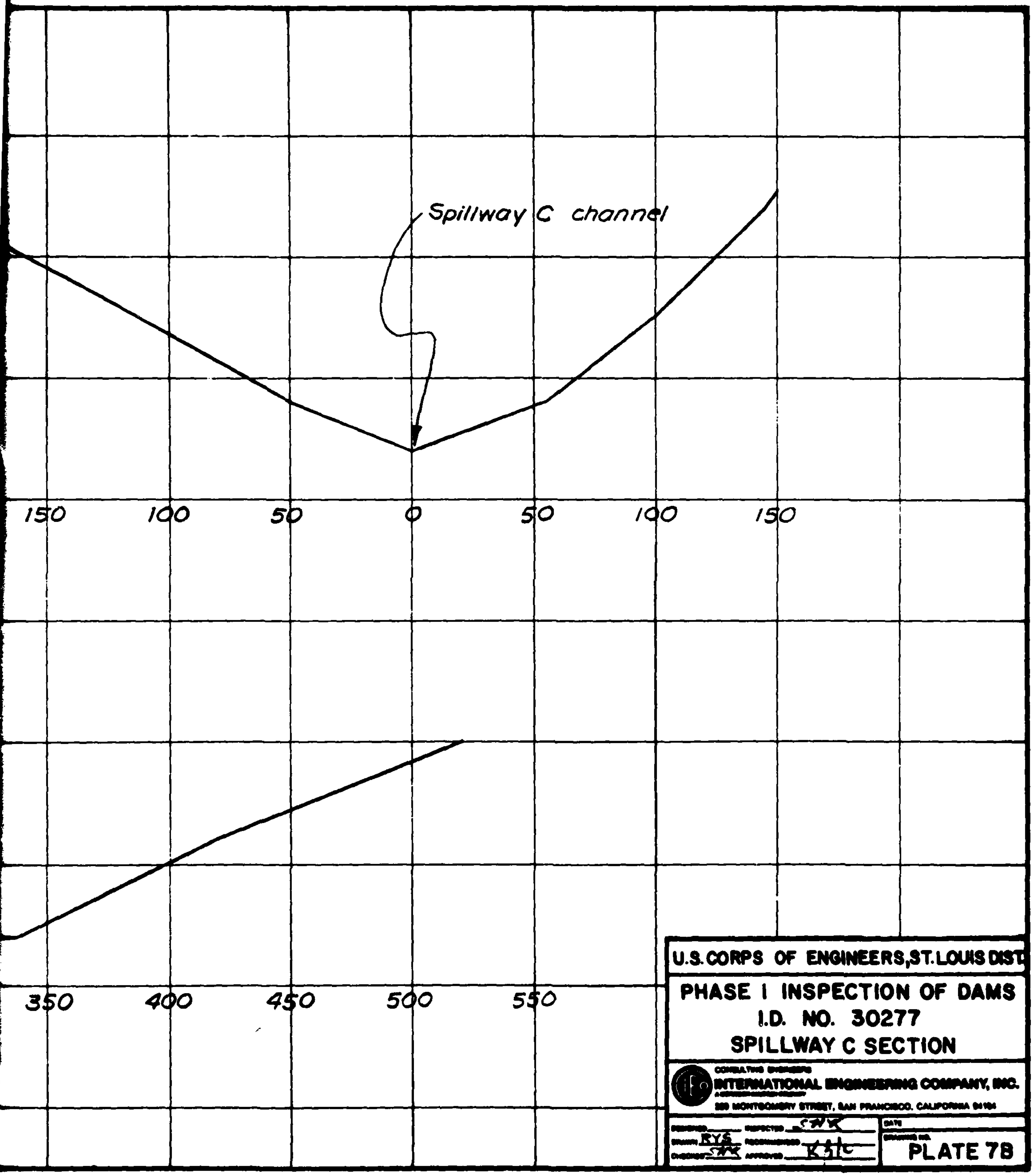
DESIGNED ____ INSPECTED SWR
DRAWN RYS RECOMMENDED ____
CHECKED SWR APPROVED ____
DATE
DRAWING NO.
PLATE 6


900
895
890
885
Spillway B
along road
700
650
600
550
500
450
900
895
890
885
Spillway A
200
150
100
50
0
50
SPILLWAY A CROSS SECTION AND ADJOINING ROAD
AT MAIN DAM SPILLWAY A CHANNEL STATION 0+



Spillway B channel-Low point
along road profile
500
450
400
350
300
250
200
Sta. 3+46
Main dam
Spillway A channel
0
50
100
150
200
ADJOINING ROAD PROFILE
EL STATION 0+93
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.
PHASE I INSPECTION OF DAMS
I.D. NO. 30277
MAIN DAM-SPILLWAY SECTION
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
PLATE 7A


917.5
Sta. 55+00
Original dam
(Railroad embankment)
915
912.5
910
350
300
250
200
150
100
920
917.5
915
150
200
250
300
350
400

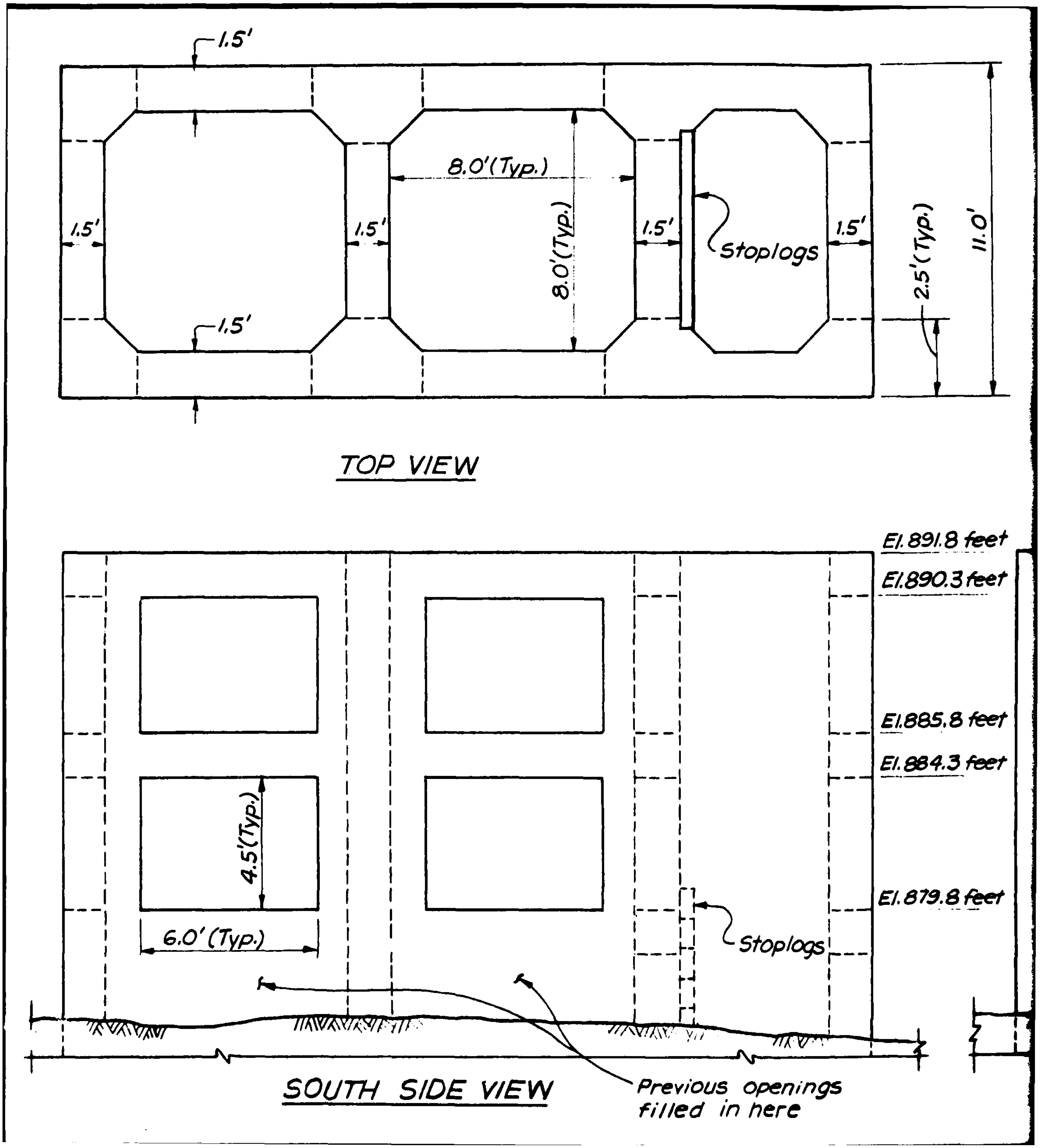


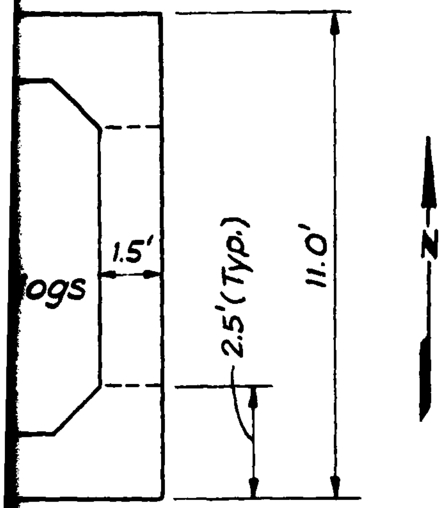
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
I.D. NO. 30277
SPILLWAY C SECTION

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

DRAWN RYS
PLATE 7B


1.5'
8.0'(Typ.)
1.5'
1.5'
8.0'(Typ.)
1.5'
Stoplogs
1.5'
2.5'(Typ.)
11.0'
1.5'
TOP VIEW
El. 891.8 feet
El. 890.3 feet
El. 885.8 feet
El. 884.3 feet
4.5'(Typ.)
El. 879.8 feet
6.0' (Typ.)
Stoplogs
SOUTH SIDE VIEW
Previous openings filled in here

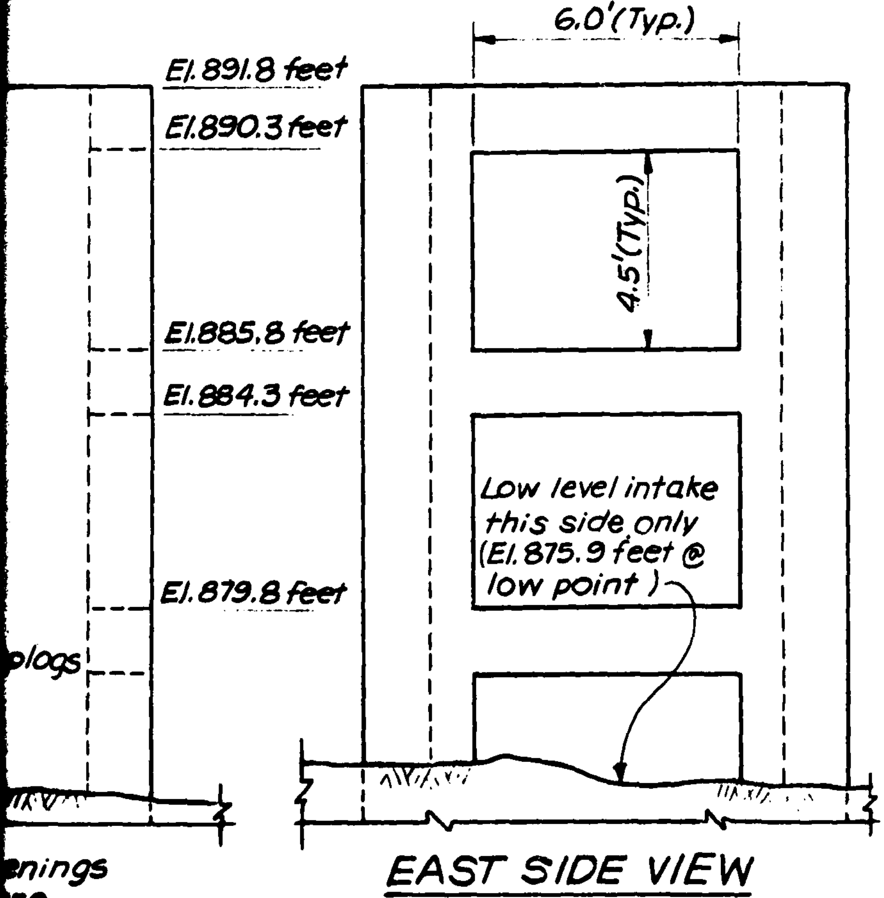


NOTE :

1. Elevations determined from hand level measurements made during field inspection on August 25, 1979 and referencing to St. Joe State Park, Mo., May 1976, 1 inch = 100 feet scale, 2-foot contour topographic maps.

REFERENCES:

1. Plate 3A
2. Photograph 5



EAST SIDE VIEW

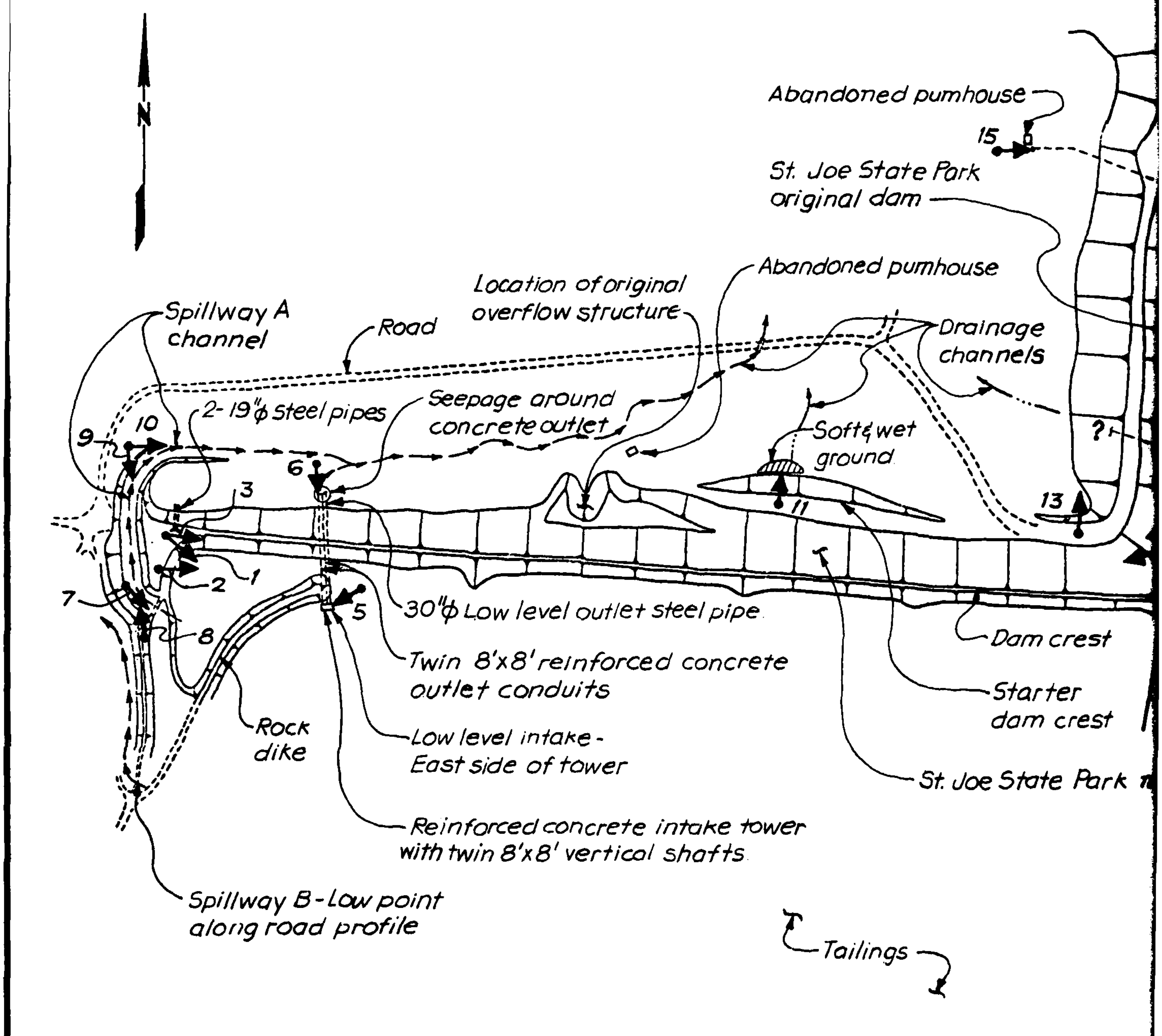
Scale 0 5 Feet

U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE 1 INSPECTION OF DAMS
I.D. NO. 30277
MAIN DAM - INTAKE TOWER

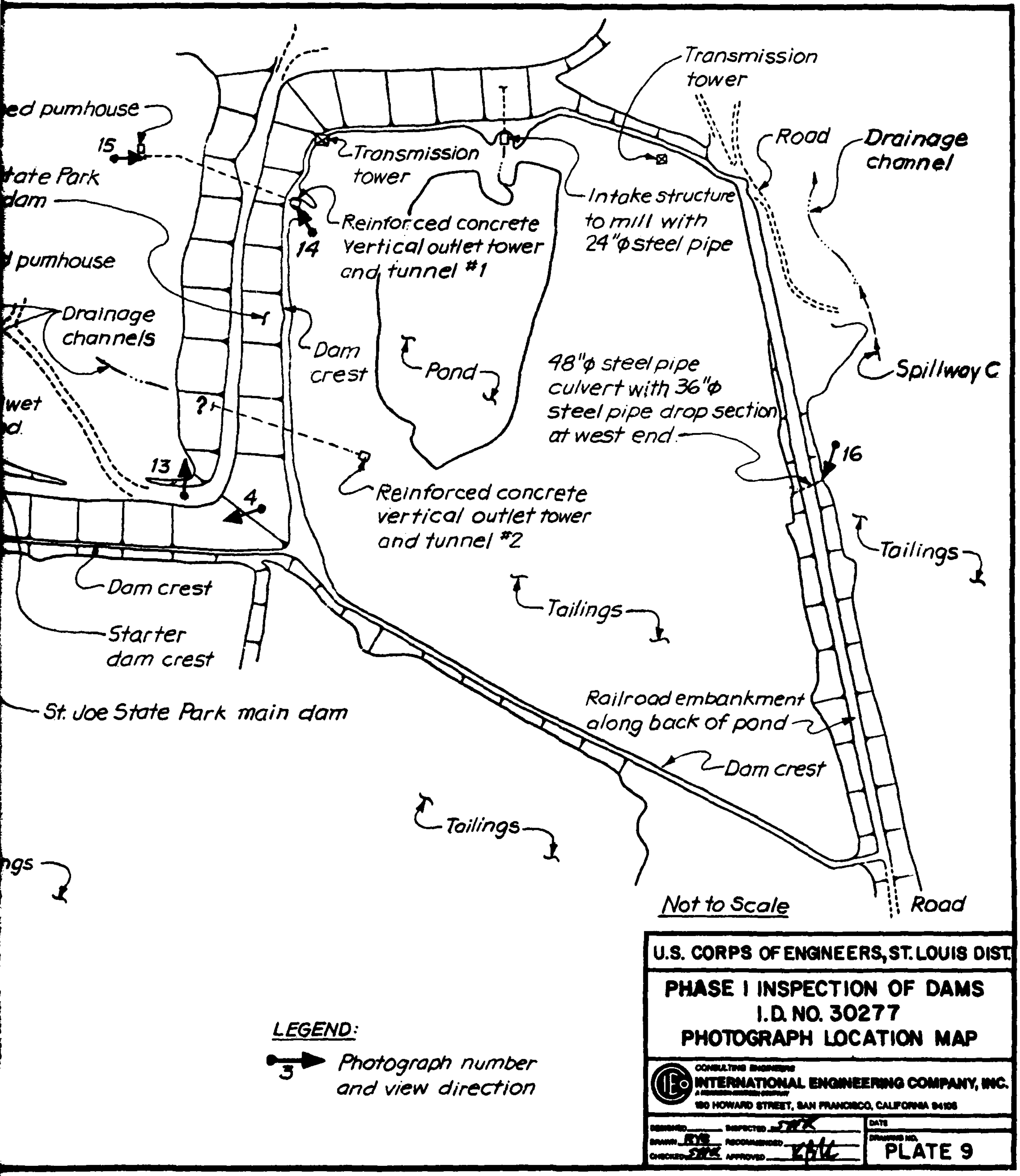
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED	INSPECTED SAK	DATE
DRAWN RYG	RECOMMENDED	DRAWING NO.
CHECKED SAK	APPROVED	PLATE 8



NOTE:

Photograph number 12 which is a view of a typical pond at the upstream end of the impounded tailings is not shown on this plate.



U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
I.D. NO. 30277
PHOTOGRAPH LOCATION MAP

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ____ INSPECTED SWK
DRAWN RYS RECOMMENDED ____
CHECKED SWK APPROVED [illegible]
DATE
DRAWING NO.
PLATE 9

PHOTOGRAPH RECORD

ST. JOE STATE PARK DAM - I. D. NO. 30277

Photo No.	Description
1	View of impounded lead tailings and drainage basin area from left abutment of main dam.
2	View from left abutment showing upstream face of main dam. Reinforced concrete intake tower is visible in the photograph.
3	View from left abutment showing crest of main dam. The original dam abuting the right end of the main dam is visible in the background.
4	View from right end of dam showing downstream face of main dam.
5	Vertical reinforced concrete intake tower near Station 7+50 of main dam. Low level intake on east face of tower is visible in the photograph.
6	Outlet of twin 8-foot by 8-foot reinforced concrete conduits and 30-inch diameter low level outlet pipe from vertical intake tower at base of dam at Station 7+20. Seepage from the conduits and around the outlet structure is apparent in the photograph.
7	View of entrance to spillway A channel at left abutment of main dam looking upstream. Dense vegetation at the channel entrance is evident in the photograph.
8	Spillway A channel at left abutment of main dam looking downstream. The dam crest is visible at the right center of the photograph.
9	View of spillway A channel downstream of main dam looking upstream. The channel curves around the left end of the dam and proceeds parallel to the dam down the left abutment hillside. The rock dike visible at the left of the photograph keeps spillway discharge away from the dam toe. Bedrock in the channel bottom is visible in the photograph.
10	View east along spillway A channel on left abutment hillside and downstream of main dam. The channel is very overgrown as seen in the photograph. The original dam is visible in the background.

Photo No.	Description
11	Marshy condition at toe of main dam at its maximum section between Station 19+00 and 22+00.
12	Typical pond at upstream end of tailings impounded behind main dam. The channel draining the pond over the tailings to the dam is apparent in the right portion of the photograph.
13	Downstream face of original dam looking north from junction between main dam and original dam.
14	Vertical reinforced concrete intake tower #1 at crest of original dam near Station 32+50.
15	Silted outlet tunnel from vertical reinforced concrete intake tower #1 of original dam.
16	East end of 48-inch diameter steel culvert through embankment at original dam Station 58+80.

AD-A105 535   INTERNATIONAL ENGINEERING CO INC SAN FRANCISCO CA   F/G 13/13
NATIONAL DAM SAFETY PROGRAM. ST. JOE STATE PARK DAM (MO 30277),--ETC(U)
FEB 80 K B KING, S H KLINE, J H GRAY   DACW43-79-C-0037

UNCLASSIFIED   NL

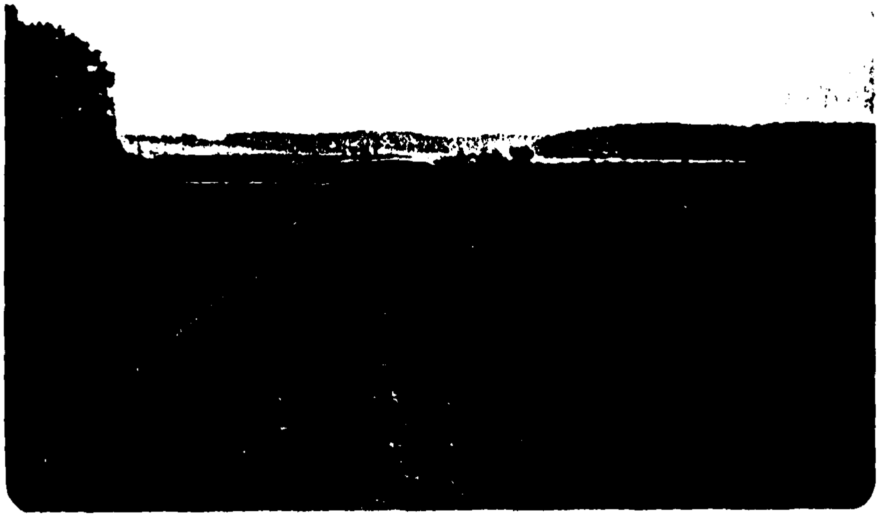
3 OF 3
AD A
105535

END
DATE
FILMED
11-81
DTIC

1

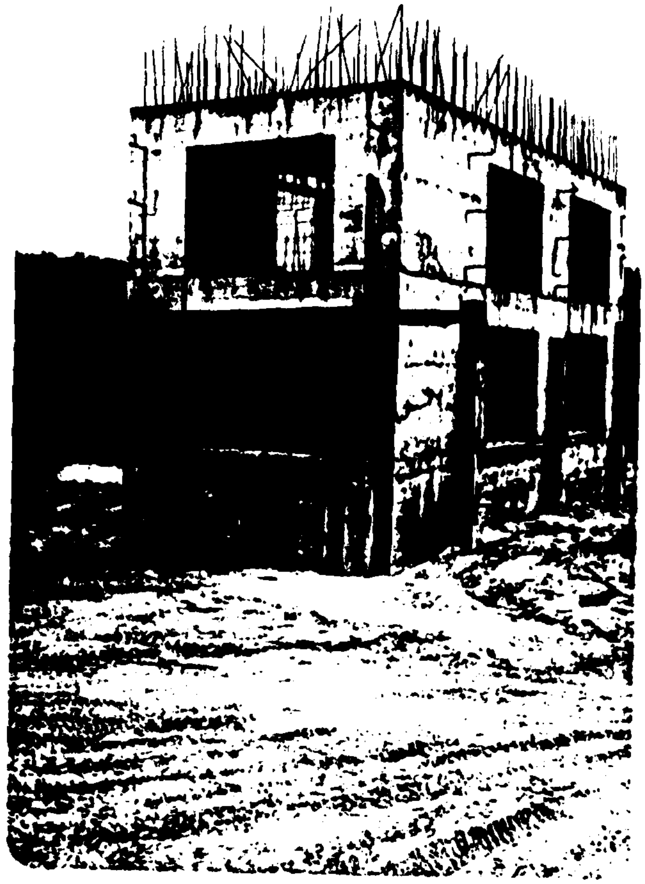
2

3



4

5



6

7

8


9


10

11

12

13

14

15

16

DATE
ILME